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CRAterre laboratory - Research Unit
AE&CC - National School of Architecture
of Grenoble - LABEX AE&CC

DISASTER-RESISTANT BUILDING CULTURES : *The ways forward ?*

PROCEEDINGS - scientific seminar / May 27-28 2013

Illustration 1- Cover : the Duna water flood in Budapest, Hungary, 2003 (Credit : Etienne SAMIN)

DISASTER-RESISTANT BUILDING CULTURES :

THE WAYS FORWARD ?

27 to 29 May 2013 / Grenoble - France

International scientific seminar organised by *CRAterre* and *Building Cultures* laboratories / Labex Research Unit *Architecture, Environnement & Building Cultures* - AE&CC / National Higher School of Architecture of Grenoble

PROCEEDINGS
&
Appendixes

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Illustration 3- The Tonle Sap lake modern and traditional raised ground floor building system, Cambodia, 2010 (Credit : Etienne SAMIN)

I. INTRODUCTION

The Research Unit *Architecture, environment and building cultures* (AE&CC) brings together the *International centre of earthen Architecture* (CRAterre) and the *Building cultures* research laboratories of the National higher school of architecture of Grenoble (ENSAG) around the notion of "building cultures".

For many years, the members of these team and others have thought over various definitions of this notion, and each of them came up with their own definition. The notion of "building cultures" is indeed a contemporary one, related to our reflection on the very act of building and to our needs of knowledge and which subsumes all the building processes (technical know-how, materials, building methods) of the past and of the present, whether they are still extent or now extinct in ancient or indigenous societies. The concept is also an incentive to rediscover the knowledge and technical expertise which were obliterated by the domination of occidental dogma, the modernization of the industrial era, an overweening confidence in the benefits of technological progress, which is notably based on the ideology of performance, the rehearsal of presupposed competitive solutions, the belief in a transnational industrialization. All of these tendencies mutilate a complex reality by reducing it to simplified and partitioned models.

In fact, industrialization and modern engineering have wiped out the constructive specificities, which properly belonged to very single culture, in order to impose an allegedly universal practice capable of responding to all the building structural problems by applying standardised norms.

Today, in order to uncover the vestiges of these constructive specificities in all the so-called "non-industrialised" societies, we name "building culture" what was formerly known as rules of the art practices and constituted a good practice taught by masters to apprentices and were handed down from generation to generation.

This study of disaster-resistant building cultures is fully in keeping with the current trend of reflection which throws a particular light on all the means implemented by different societies throughout the world when confronted with natural hazards in order to answer an essential need, which is the protection and shelter only a settling is supposed to provide.

This study is also in keeping with a societal need that brings together, on one hand the illegitimately so-called "emerging countries", and, on the other, our so-called "developed western countries". In many of these countries people can not always afford to use industrialized materials such as concrete and steel, nor can they master the sophisticated knowledge and norms requires by technical regulations that transnational construction lobbies impose. And yet, they

are confronted with multiple, violent and recurrent natural hazards. On the other side, both "emerging" and "developed" countries are also confronted with increasing numbers of natural hazards and risks brought about by a global concern on climate change, by the economy necessities of reducing the cost and consumption of energy. In this context, advanced research on natural materials which requires much less energy for their transport and transformation, is led to revert local and traditional practices our societies have almost entirely forgotten.

The research now continued on building cultures is therefore in line with contemporary concerns and brings together in a universal way, with a positive meaning, the needs of all sundry, since we have to face global threats which can endanger each of us.

This is why the CRATerre Laboratory within the framework of the Labex AE&CC established in 2012-2013 a global survey of the research carried out in the field of disaster resistant building cultures. The aim of this work is to contribute to the definition and consignment of the different research orientations on this topic. This project was launched in mid-october 2012 calling on several experts from the Habitat team of CRAterre along with external personalities.

The idea was first to set up an inventory work of researches and of researchers who were interested in this topic and who are still interested in it, to probe the reasons why they were interested and the finality of their work, to spot out the trends, constraints, wants and needs in order to map out future research orientations.

After defining the lines along which our work and methodology will be carried out, we set out to explore our internal resources by consulting the existing bibliography, setting up fairly exhaustive bibliographical lists, identifying networks, organizations, persons of note or likely to be interested in this problematic, and, along the way, by defining the contours of a future database on this topic.

This initial work was brought to an end with the organization of a seminar of reflection and exchanges which was held at ENSAG on May 27- 29 2013, whose aim was to finalize and publish suggestions of research orientations on disaster resistant building cultures. The outcome of this seminar is consigned in the proceedings which constitute our present publication. It compiles the working groups' syntheses and the papers proposed by all the contributors. All the digital appendices are compiled in a file joined to the present document in order to provide an easy access to all the elements of knowledge given and shared during these few days (powerpoints and short movies presented, audio recordings, group pictures).

Dear colleagues,

First of all, on behalf of the school and of the LABEX Architecture Environment and Building Cultures I would like to welcome you to our School of Architecture (ENSAG). As a short introduction, I would like to say a few words about the purpose of this seminar on Disaster Resistant Building Cultures, and the specific interest of CRAterre and of the AE&CC Labex for this initiative.

This is 40 years ago Craterre started developing research and other related activities in the field of earth construction. 30 years ago, as was the trend at this time, we first focused on the development of "appropriate technologies", and the way they could be implemented for people's benefit, but we soon realized that this approach had its limits and that we should look for other ways, more specifically by taking into account the existing local building cultures and trying to learn first from the people's technical «know-how» and its potential evolution in the future.

Consequently, approximately 20 years ago, we decided to readjust our approaches, taking as a starting point people's knowhow, so as to ensure their local intelligence was vindicated. Ten years ago, we started being involved in post-disaster situations, where these concerns proved to be even more relevant. Since then, we have prioritized this approach.

In a context of vanishing of cultural and architectural diversity, a local intelligence grasp of the environment of the utmost importance to try to solve todays' problems, and avoid a systematic shift to moderns technologies that, actually, rarely provide the expected results. In the case of disaster situations, the way people build and organize themselves, and the technical solutions they adapt to cope with them - even if they seem insignificant or at a very small scale - can give an insight as to how one can be prepared to face and survive disasters and can offer clues to better resilience to natural hazards.

In this respect, there is a need to think in terms of synergies and simultaneously to take into account Urgency, Rehabilitation and Development, as well as Research, Field applications, Training and the dissemination of "good practices".

What we realized is that the concepts and ideas that we had thought over had also gradually become a concern for other professionals in the field and also for a variety of organizations. So what we have been doing recently is to increase our exchanges with others to reflect on strategies to deal with the "local building cultures". The challenges are formidable when there are disasters, so we do feel that there is a need for more consciousness around the world to address these issues sensitively.

Over the last few years, we have been trying to have exchanges on different occasions. First, we have been organizing several small-scale seminars. Now we have more financial thanks to the LABEX dotation that we obtained two years ago. Within these conditions we have been able to decide to organize larger seminars, not only to have exchange but also to work out the needs of our research, its main axes of reflection for the next few years, so as to be better prepared to cope with post-disaster situations, and to help people to be better prepared when disasters strike them.

We are very happy that so many of you have been able to respond positively to our call for participation, coming from so many countries and bringing along all your experiences. Hopefully this meeting will be extremely fruitful, and I would like to thank you all for having responded so positively, and more especially those of you who have come from very far.

Before we start, I would also like to thank those who have been involved in the preparation of this meeting. I would like to mention first Georgia Poursoulis who has been working together on this event for several months with Etienne Samin, who is sitting next to me, ready to present you a slide show on their research work. I also need to mention Philippe Garnier and Olivier Moles who planned this meeting long ago and also worked hard for its preparation. There is also Marina, Laura, Murielle, Zachary, who all have brought their energy to ensure that this event runs smoothly, and I would like all of us to give them all a round of applause for the hard work they have put into the logistics. We also need to recognize collectively the work done by all the members of the administration of ENSAG as well as a few volunteer students of the DSA Terre who have been helping us for the organization over the last weeks. Thank you again to all of you for being here, I wish us a very fruitful seminar!

Thierry Joffroy
Architect - Researcher
CRAterre-ENSAG
Labex AE&CC Coordinator

Welcome to you all,

Thanks to all those who have answered the invitation of AE&CC and CRAterrre to participate in this seminar on disaster-resistance building cultures.

I convey the apologies of Hubert Guillaud, the director of AE&CC and of Patrice Doat, director of CRAterre who could not join us today, along with those of J.M. Knop, the director of ENSAG.

As head of the building cultures laboratory, I would like to focus on the expression "building cultures" which is the notion that has brought together our two laboratories within the same research unit. This notion has been worked out here, at the Grenoble School of architecture for the past four decades, first by the founders of the "Dessin-Chantier" (Drawing-Building site) course, Sergio Ferro, and of CRAterre, Partice Doat. The notion has been developed and honed in by Cyrille Simonet, Philippe Potié and Hubert Guillaud. It has laid the foundation of the Grands Ateliers de l'Isle d'Abeau, run by Patrice Doat and Pascal Rollet. One may even go as far as to say that this notion, beyond our laboratory, is the kingpin of the school of architecture as a whole.

The concept of building cultures implies a way of looking at architecture which combines the two notions of "cultures" and "building", each of them being respectively related to anthropology and technology, in other words they are to be linked to human societies, in their diversities, traditions, and representations, and to the realm of technology.

As far as the world of architecture is concerned, to abide by this notion means that action supersedes form. To act is of the essence, and the act of building is the function which building cultures are concerned with. In our opinion, the better part of the building project links up with the project of dwelling or settling down. As a result anything that partakes of the act of building – building materials, technical knowhow, required tools, atmosphere monitoring, building maintenance – is invested with an ethic dimension, since it is accountable in terms of location, resources, knowhow, environment, consumption and recycling.

To be interested in architecture's joint cultural and constructive dimensions means that it is not merely a technical, functional and aesthetic object but that it is also the outcome of a project related to a complex practice whereby man occupies a place to live, work and create.

The scientific project of AE&CC bears equally :

- ways of dwelling/settling/living, using, maintaining, managing and developing housing (as a "built environment"),
- building material used, their origin, extraction, transformation and delivery on building sites,
- technical implementation, means, knowledge and technical knowhow used,
- environmental energetic and thermic constraints, as far as they can be established and assessed,
- organisation, role and valorisation of the various agents involved at each level of the overall programme.

Bearing the above criteria in mind proves particularly useful when it comes to assess the suitability of the project to the environment. It helps to better evaluate the social and economic impacts of the project. It also helps to have a tentative assessment of local, natural and human resources. Such criteria also serve to assess the manner in which the building project contributes to the local well-being, development and to further benefits it can bring about.

Hence, the notion of "building cultures", in the plural, allows us to acknowledge the diversity of cultures which have developed and are still developing in local contexts their intelligence, because of, or in spite of the specific environmental conditions which either stimulate it or stunt it What we also learn from this notion is how they have evolved at different periods, helping the project manager to implement the idea of "thinking globally and acting locally" and thereby to better value people's creations in their local context.

In architecture more than in any other fields perhaps, the local experience stands on an equal footing with the industrial innovation and mass production. It this way, by contributing to environmental quality and to grey energy economy, local development is fostered and global equilibriums are maintained. Two basic demands are thus efficiently met : sustainable development and the respect for cultural diversity.

The title given to the meeting, which begins today, cannot be underestimated. The phrase "Disaster resistant building cultures" involves an attempt to assess how this specific approach to building culture can pave the way for a research founded on the strengthening of the synergy between urgency, rehabilitation and development, but also on the triptych "research, implementation and formation" which is the crux of our Labex programme, whose aim is to better understand and be in a better position to cope with the challenges of disaster risk reduction, resilience and sustainable development.

The organising team of this meeting is convinced that in order to meet these challenges, the notion of building cultures is fully relevant. In the days to come, our aim is to think together on how we can move further on and make a great jump ahead.

Once again, welcome to you all. I wish a good and fruitful work during these days and even beyond.

Anne Coste, HDR
Professor HCA, architect - historian,
Director of building Cultures laboratory,
AE&CC, ENSAG

Illustration 4- workshop group (Credit : Mauricio CORBA BARRETO)

Contextualisation

Following a general debate held in plenary session, five working groups were formed to identify key issues and priorities for research on Disaster-resistant Building Cultures (DRBC), defined beforehand by the state of the art (CRAterre preliminary research) and the ideas that came out of the first day of the seminar:

1. Knowledge, History and Atlas of DRBC
2. Transfer of knowledge: from an intangible and non-formal acquisition to an institutional supervision
3. Characterization and modelling / Integrated approach to engineering
4. Communities and DBRC research: potentials and limitations (or "how to bridge the gaps that separate the academic world and the affected populations?)
5. Terms and methodologies for the integration of DRBC as part of the risk preparedness and the implementation of appropriate intervention strategies.

Together, the five groups defined a range of starting points and assessments that should be considered when developing research on DRBC. General ways of research were selected, along with specific research lines for:

6. Transversal research priorities,
7. Fundamental research,
8. Applied and operational Research: activities and outreach programmes,
9. Dissemination / Diffusion / Teaching.

Preamble

The study of DRBC represents a potential to :

- improve the resilience of populations facing natural hazards,
- ensure a transition from "Emergency response" to "Development planning".

Therefore, DBRC fosters reducing the social and physical vulnerability with simple means, since they are mostly based on the appropriation and recognition of their own knowledge, in the context of pre- and post-disaster. Research should help to avoid knowledge loss, especially during and after disasters, which can represent breakdowns in the social and physical life that also affect the local systems of knowledge as well as the local economy and social balance.

The following suggestions concerning ways of research highlight the essential issue, which consists in radically breaking down the dependence and gross exploitation which the economic paternalism of development aid and cooperation programmes often brings about. As far as we know, there is no proof that a country that has received such aid has been able to develop independently.

DRBC are in-situ knowledge and should be considered as such. The study of DRBC practices

highlights how the local context can be taken into account and how the population's knowledge concerning its needs and aspirations is likely to offer valuable information towards effective risk reduction policy-making and strategic planning. A risk linked to de-contextualized knowledge has been noticed, just as the importance of DRBC at their level of implementation is to be valued. In this respect, the anchoring of "participatory active research" within long term processes and the importance of monitoring projects before, during and after their implementation, is to be adopted as it is often extremely relevant for any sustainable approach.

Lastly, knowledge bases that are necessary to tackle the questions raised by DRBC already exist in many fields of the social science.

1- Transversal research priorities

1.1- Create links between academic world and involved communities

1.1.1- conduct an inventory of existing methods of community mobilization and research appropriation mechanisms (knowledge, practices, etc..),

1.1.2- develop programs so that communities and the key players/actors can :

x- be on board as stakeholders and members involved in the research activities, collection of knowledge, etc.,

xi- carry on with research development,

xii-use the research results independently in projects they will be able to implement and evolve.

1.1.3- develop truly and easily appropriated interdisciplinary approaches in order to avoid to "freeze" knowledge by assigning them to a field or a discipline.

1.2- Integration, evaluation and monitoring

As part of an integrated approach, it is necessary, on the one hand, to assess the needs and the context well before research or a specific action is undertaken, and on the other side to identify as a matter of priority the existing local dynamics

1.2.1- consider carefully and in collaboration with local stakeholders the relevance and usefulness of the research activities in a given context,

1.2.2- take into account the specificity of each stakeholder group and collectively develop specific tools and support with appropriate language, taking onto account vernacular taxonomies and categorization of knowledge and practices related to building cultures and disasters.

1.3- Vulnerability reduction and risk prevention

1.3.1- consider Pre- and Post- Disaster periods to maintain a sustainable action,

1.3.2- focus on an approach which aims at reducing vulnerability (rather than "risk"), on natural hazards preparedness approaches and on resilience increase,

1.3.3- towards development planning: put more investment to develop “methodological approach” than “technical solution” and emphasize the “social” rather than the “technical process”,

1.3.4- consider “small risks” with regular occurrence, which may have much more impact than “great – but exceptional - disasters”.

2- Fundamental Research :

Research has to be implemented within a wide approach with complementary themes that comprises:

2.1- Atlas /database

2.1.1- identify and document local DRBC,

2.1.2- create a time dependant database /atlas for the diffusion of the knowledge on DRBC and the reinforcement of the connection and the sharing of information between the research areas, (accessible to all kinds of users and associated with continuous surveys).

2.2- Technical characterization of DRBC:

The difficulties of modelling vernacular buildings and evaluating their potentials imply to:

2.2.1- promote and systemize the use of existing scientific research results related to disaster resistant building practises

2.2.2- define the appropriateness and the relevance of the generation of analytical models,

2.2.3- assess the potential of DRBC :

i- analyse the existing tools of modelling in terms of characterization and validation to adapt to the specificities of DRBC

ii- assess the structural behaviour of buildings and the resilience of the concerned communities for each type of natural hazard (including non-constructive strategies and practices)/ resilience for each type of hazard, and propose disaster resistant constructions for communities,

2.2.4- develop the knowledge to learn how to «read», «analyse» and «pick out» the DRBC on the field in order to identify typologies of building that are structurally and socially appropriate (eg development of good practices statement, tools) by:

i- undertaking specific case studies,

ii- proposing experimental tests on building typologies,

iii- proposing solutions to «improve» the vernacular structures according to local perceptions of comfort and needs within the current context (the use of contemporary materials has to be carefully considered in the absence or lack of natural resources).

2.2.5- Promote research and experiments on ecological and economic habitat in terms of resistance to disasters: a study of various construction parameters that promote economical materials by assessing their impacts according to social and environmental goals (integrate global trends, including the climate).

2.3- Characterization of Processes and programmes management

This part involves researches on the already existing programmes in evaluating the pre- and post-disaster situations and the local development programmes in hazards-prone areas that both take or do not take DRBC into account:

2.3.1- compiling existing documents and past projects which were implemented and based on local building cultures,

2.3.2- compare different case-studies (through time, location, nature of the project, etc.) to induce a better understanding of the impacts of pre-/post-disasters and development programmes within a territory, and in the long-term in hazards-prone areas,

i- document and evaluate the effects of applied research implemented with the communities (evaluation of the degree of sustainability of a project).

i- research on the programmatic continuity: documentation and assessment of the effects of the programmes' implementation (applied research, outreach, awareness, work with communities, etc.): viability assessment, study of the relevance and degree of replication,

ii- research on cultural continuity : rebirth or importation of knowledge and know-how after the impact of an intervention based on DRBC

iii- create a tool to assess the impact of the «time dimension» ("Time investments" and "Time use") given to the elaboration and to the implementation of a project, in the sense that we consider "time" as a «fundamental investment» in the same way as financial, human or material investments.

2.4- Characterization of the social demand and needs ; research on the mechanisms and means of programmes appropriation

It is sometimes difficult to enhance local dynamics, or to foster existing practices. It is important to guide the researches aimed at studying the degree of adequacy between the programmes' design and the given context, with respect to the relevance of the response given to a real need (expressed or not) and to the emergence of appropriation mechanisms towards the projects ("acceptance" – "adoption" - " adaptation"). This research aims at structuring information on the characterization of the social demand, particularly concerning the following points:

2.4.1- comprehension of Risk-taking linked to natural hazards and habitat:

i- study of the influence of the social vulnerability on the perception of risk associated with their habitat (ability to resist or not the impact of a natural hazard)

ii- study of the adequacy between the social perception of risk and the DRBC: the influence of the social vulnerability on perceptions pertaining to the conservation of knowledge as a "capital" is crucial,

iii- study of the influence of the social vulnerability of people on the retention / destruction of built heritage (buildings, facilities, infrastructures, etc..) and therefore on its physical vulnerability

2.4.2- study of local adaptation strategies that are developed facing the recent rapid changes (including climate change),

2.4.3- study of the factors of resistance to change and especially to the implementation of programmes for disaster risk and vulnerability reduction: conditions for success and failure of projects based on DRBC (blockages, perception of the inadequacy of the projects to their context, to the local needs, etc.). The expected result will be to allow the implementation of a reverse strategy to develop tools or approaches in order to unlock these situations and strengthen the potential lever arms of DRBC.

2.4.4- identification of social levers that foster/allow DRBC to survive or to be mobilized, replicated and appropriated through time: to consider the way such knowledge and practices stand up to the «social norm» (how they are accepted or rejected by the depositories of this knowledge),

2.4.5- inventory of research and DRBC based projects that have proved sensitive to social needs and their evolution: study of the mechanisms that make DRBC responding to social needs and are adapted to them in accordance with their evolution within a social group.

3- Applied and operational Research : activities and outreach

If the "risk culture" has been lost, if communities' resilience has been reduced, they have to be awakened again, notably through the awareness of everyone to the reality of risks, through vernacular knowledge stimulation and to an adaptation of the programmes to the daily life of the population:

3.1- Local development in disaster prone areas: a generic methodology to be adopted and systematically integrated in programmes

3.1.1- analyze the local mainstream development policy,

3.1.2- evaluate and make the inventory of the local disaster resistant building cultures,

3.1.3- understand the different ways of knowledge construction and transfer for their diffusion :

i- type of knowledge concerned

ii- knowledge systems and local ways of transfer,

iii- knowledge keepers,

3.1.4- improve the quality control of structural elements in post-disaster (re)

construction,

3.1.5- adapt elements of local architecture to contemporary needs (comfort, functionality, compatibility with economic activities, etc.).

3.2- Means of research appropriation by supporting the local stakeholders:

The challenge posed by the appropriation of research and project management is fundamental. In fact, the post-disaster reconstruction is in most cases carried out only by local people. It therefore falls within the domain of an architecture without architects, without "project" or external support. Taking into account this reality would probably reorient international aid and finally be a relevant alternative to mere assistance. The support of international aid would be more efficient and legitimate if it can finally have a positive impact on the vindication of the local disasters-resistant cultures and practices which people are familiar with. Ultimately, it can promote pragmatic and accessible improvements paths. The following main lines of the research ought to be appropriated by local actors:

3.2.1- develop partnerships and bilateral research to reflect on a radical political transformation of power relations so that local communities, practitioners and scientists can truly work together through the study and application of the DRBC :

i- develop methodologies and tools for local mobilization in the research / analysis phase,

ii- diagnosis of post-disaster pathologies (recording data),

iii- inventory of building cultures according to their level of resilience (data analysis),

iv- compile books and elaborate guidance to build anew safer constructions (data transmission),

v- design a variety of alternative solutions (in terms of technical and financial accessibility) to enhance local creativity and give the opportunity for people to be inspired by local building knowledge, to reproduce and disseminate it in order to create their own solutions.

3.3- Time : link relief, rehabilitation and development

Empowerment aims to ensure the viability criterion of the projects while maintaining their sustainability over time. Development, in essence, requires time, so an adaptation of the vision, of the assessment methods and of the temporality given to the aid agencies programmes are required. It is a matter of new intervention strategies so that the link between emergency or development actors takes place without interruption and avoids making people dependent.

3.3.1- focus on strategic support, research and energy in pre-disaster phases and risk reduction to reduce vulnerability (improvement of settlements and disaster preparedness before the crisis),

3.3.2- develop pilot projects based on the results of the case-studies comparisons (e.g. fundamental research / Characterization of intervention processes),

3.3.3- develop partnerships between specialized builders in « disaster-resistance », “community facilitators (leaders)” to reduce mistakes,

3.3.4- ensure effective monitoring through time « during and after » the programmes' implementation (this would facilitate the next steps of case-studies comparisons).

4- Dissemination / Diffusion / Teaching

4.1- Awareness and diffusion

Enhance the image of DRBC towards local populations and decision-makers in showing that techniques and knowledge coming from DRBC are in keeping with the specific threats related to natural hazards within disaster-prone areas: the mobilization of local materials and know-how is an appropriate response to a reasoned and reasonable development.

4.1.1- support the use of local knowledge in developing:

i- qualifications and rules of « good practice » based on relevant local building materials and their use for disaster-resistant construction,

ii- tools for dissemination and diffusion based on local organizations and social structures.

4.1.2- strengthen and sustain exchanges on definitions and notional bases relating to DRBC between each country involved in research programs to develop a more comprehensive view of the meanings of each of the actors and avoiding monistic definitions that can be frozen by cultural determinism.

4.2- Transfer of knowledge, tools and methods:

4.2.1- support for the use of local knowledge in developing appropriate guidelines: develop skills and rules of “good practices” inspired by DRBC to contribute to a positive influence on building codes in disasters-prone areas,

4.2.2- generate a matrix that inform people about natural hazard and appropriate behaviour related to the habitat installation, construction, maintenance, etc.

4.2.3- share tools and methods, consider research and projects through a local approach (bottom up) rather than institutional approach (top to bottom).

4.2.4- incorporation of “participatory development facilitation / animation” within educational institutions (schools, universities, research laboratories, etc.).

4.3- Enhance development of research

4.3.1- create and organize a network with all stakeholders involved in the research and in the field work,

4.3.2- Organize and locate appropriate regular venues for workshops to dis-

seminate and popularize scientific findings and publications in a critical and progressive way in order to :

i- foster scientific and political recognition of the contribution of local building cultures and practices dealing with disaster-resistant strategies,

ii- exchange ideas about the research outcomes in order to have an impact on fieldwork practices and actors,

iii- popularize research results and share relevant methodologies to both peer academics and target communities, so that they are understandable, available and appropriated by all stakeholders (academics, practitioners, people etc.).

4.3.3- create a database for the dissemination of knowledge about the DRBC (accessible to all types of users and associated with continuous monitoring). This database aims to strengthen the exchange of information between the areas of research and fieldwork activities.

Illustration 5- The participants and the contributors of the seminar (Credit : Mauricio CORBA BARRETO)

II. SEMINAR OUTCOMES

1- WORKING GROUPS' SYNTHESES

2- CONTRIBUTORS PAPERS


Points
Materials
Relevance

Illustration 6- workshop syntheses presentation (Credit : Mauricio CORBA BARRETO)

1- WORKING GROUPS' SYNTHESES

Group 1 : History - Knowledge - Atlas

History, Knowledge and Atlas are the three words defining the basement of the present workshop. History is the link between all the disciplines involved in the collection of knowledge about the DRBC. The collection of all the knowledge produced by all the disciplines found its finality in the Atlas.

History is also the thread from past to future, based on time consideration, which is the purpose of the workshop: to found and collect the DRBC used in the past through the world in order to understand their use, social context and way of construction in the present, to revival them for risk mitigation in the future as an alternative to engineered constructions in low economic areas.

Knowledge is produced by different fields and different categories of people. It is academic and practical, the result of scientific work and know-how of generations of people, transmitted by experience and oral diffusion.

Many disciplines, in non-exhaustive way, participate to the collection of DRBC knowledge:

- Environmental sciences, as geology, geophysics, seismology, climatology, palaeoseismology, sedimentology, geomorphology, archaeoseismicity… participate to the hazards better understanding.
- Social and human sciences, as history, archaeology, architecture, sociology, ethnology, economy… participate to the communities' behaviour, cultural and cultural practices understanding.
- Practical sciences, as engineering, technical practices… participate to the buildings behaviour understanding.

Scientists of all these disciplines, but also local technicians and peoples who have the memory of past events and of DRBC reason for being, participate to the collection of knowledge.

Atlas is an inventory, a collection, a mapping of knowledge. But as a collection it is static and limited. We consider that the collection of knowledge in a multidisciplinary way from all the fields involved in the DRBC recognition and understanding will be more efficiently produced by a database, time dependant. This database will be the result of the common work and exchanges between all the fields involved produced by a network of researchers of the whole world with strong communication between every parts of the process of risk mitigation. Communication is important between researchers, stakeholders and policy makers, between researchers and populations. The database must be accessible to the scientists and to the population and other users. The aim of the database would be the universal diffusion of the knowledge on DRBC.

Future : we decided to add the world future to our reflexion. Because hazards are not static but recurrent, they need to be continuously observed by surveys. For that, all the scientific fields involved in the process of knowledge acquisition must be continued and reinforced in the future in order to produce a better prevention for the populations in hazard prone areas.

In order to produce the database we need to reinforce the connections between the fields and the sharing of information. For that a common language must be established between all the fields.

The multidisciplinary way show that the scientific fields are dependent, connected through transversal links. Researchers need to work together with strong connections between the fields. For that three ways of connection are proposed among others:

1. To build specific research projects in multidisciplinary way, involving all the scientific fields concerned by the DRBC recognition and risk mitigation process. That means to build a common language, and an understanding of every participant way of thinking.

2. To regularly organise workshops with all the fields involved in order to exchange ideas and results.

3. To organise the network between all the parts involved in the process. That means to establish communication and exchanges between fields and actors.

Researchers have to produce documents accessible to the populations and propose training programmes, or other means of communication, in order to diffuse the knowledge and information to the populations concerned by the DRBC in hazard prone areas.

Group 2 : Transfer of knowledge

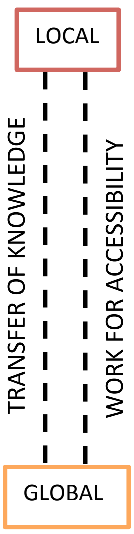
The seminar on disaster resistant building cultures showed how their study represent today a key issue to reduce the vulnerability of population facing natural hazards. Simultaneously, a tendency of standardization of knowledge is often mentioned. Focusing on ways to transfer knowledge, in consonance with the local settings, seems to be an essential issue, especially in disaster prone areas. Thus, disasters represent breakdowns in the social and physical life, which can also affect the systems of knowledge. It is therefore essential to study not only how people can develop and practice disaster resistant building cultures, but also to understand and emphasize the process of transfer of knowledge between and within the communities. It aims to empower communities by the reappropriation and valorization of their own knowledge, so as to improve both the social and technical aspects of housing and to complete disaster mitigation.

In such a work, we agreed that the first prerequisite should be to identify, in each context, the different local knowledge systems (considered as cumulative body of knowledge, know-how, practices and representations) and the consequent knowledge holders, local systems of transfer, along with the type of knowledge concerned. We noticed the importance of taking into account the specificity of each target group. Besides, we recognized the significance of social representations and perception of housing, natural hazards, and environment. We raised therefore the difficulties of dealing with situated knowledge, but the importance to consider it in a meaningful context, remarking the potential risks of "out of context" database.

In any case, we emphasized the need to focus first on the quality of existing building and human resources, as a base for the transfer process, before trying to implement external solutions. It appeared to be a good mean to maintain the existing dynamics in the communities.

Box 2 : Set of tools

Actors	Local communities	Researchers	Professionals	Decisions makers	Ngo's	Medias	...



- Document local knowledge
- Focus on a greater commitment to youth and educational activities
- Identify and conserve the material supports of knowledge
- Make people value their own knowledge
- Define appropriate language and tools
- Mediation
- Transfer tools and methodology that can be taken up by people
- Match research investment and field reality
- Develop awareness on natural hazards and disaster resistant building cultures
- Combine local knowledge with worldwide experiences
- Networking / dialogue within and between communities
- Rely on existing literature
- Interdisciplinarity

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When considering the potential ways of transfer, we concurred that attention should be paid to the different scales of knowledge construction, in between local and global levels. We often speak about the local/global opposition as the one between the world of scholars' communities and their local fields of study/action. We use here "local" for every knowledge situated in the local space (whether geographical or social), and "global" for the interaction between those different spaces. We therefore listed some potential ways to transfer knowledge at each scale, which can be applied to all the actors concerned at their own scale (Box 1).

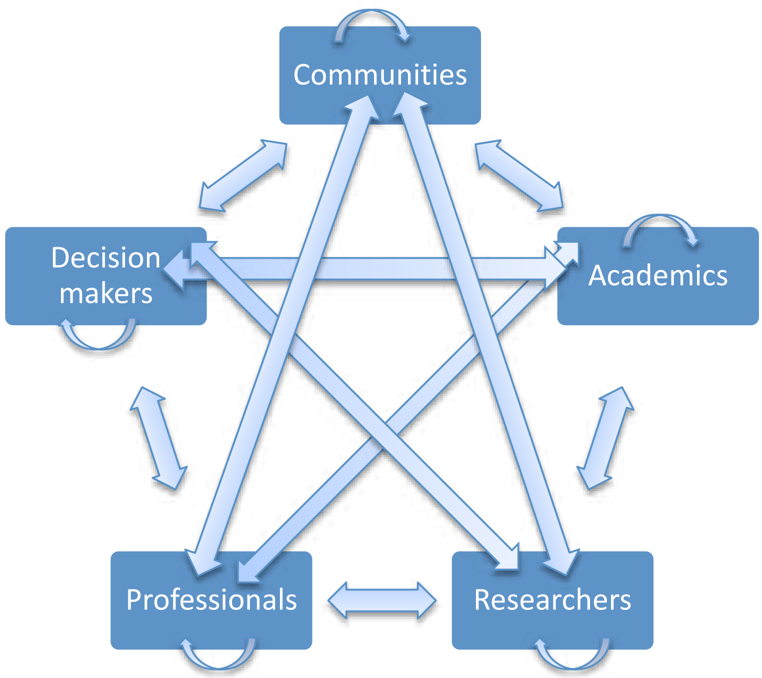
Hence, a wide range of tools already exist when thinking about transfer of knowledge. We selected a set of them (Box 2). This list is not to be exhaustive, and is meant to be adapted to the local context analysed beforehand.

Box 2 : Set of tools

- Trainings and on site trainings,
- Workshops,
- Networking,
- Communication,
- Guides books,
- Reference books,
- Manuals,
- Awareness,
- Exhibitions,
- Educational materials, Awards,
- Pamphlets / flyers,
- Videos, Medias,
- Documentaries.

Therefore we raised the importance of dialogue between all the actors involved in transfer of knowledge. Bridges should be built among researchers, field workers and local communities (Box 3).

Box 3 : Interrelated actors to transfer knowledge



Eventually, it is in our hands to build on the seminar outputs and disseminate the results of our reflection. Some of us are already trying to implement these orientations in different of our projects and actions (Box 4). We should use networks that we are involved in to share and identify resources, while going on working with community based organization. It would also be of interest to try to set up a pilot project, so as to test transfer methodologies in different contexts, and to embrace the complexity of knowledge transfer in disaster prone areas.

Box 4 : Short Term Actions

CRAterre Seminar outputs – for July 2013

To use NGOs & Networks involved in awareness activities :

- PROTERRA: Awareness activities among populations for the mitigation of risk.
- SDC Swiss Cooperation Agency + CRAterre sharing of technical knowledge & direct site application.
- Community based organization 'Construye Identidad' – contact academics & communities.

To use CHAIRE UNESCO networking to identify resources to develop activities

Remark : While we tried to consider the question of transfer of knowledge related to disaster resistant building culture in a general context, the following remarks reflects more our considerations as researcher. This reflection is therefore non exhaustive and should be completed in the future with same kind of discussion groups including field workers and members of local communities.

Group 3 : Characterization and validation analyses

Objectives

The two major objectives of characterization and validation analyses are :

- to evaluate the structural behavior/resilience of a particular building type under a particular hazard,
- to propose disaster resilient constructions for communities.

The structural behaviour of structures can be reproduced by numerical and analytical tools. However, this procedure is not straightforward due to limitations to our knowledge about the structural building typology of traditional building systems, as well as the mechanical properties of certain materials, the evaluation of the range of effects of certain hazards, and certain limitations with available software for modelling.

During the design of Disaster Resilient Buildings, some key issues and priorities were identified by the experts. Discussion of ideas was concentrated on vernacular houses. However, this brief introduction can be useful for proposing extended studies to larger structures and historical monuments.

Our effort in this summary is to give general ideas to approach the problem. But, in order to determine a structural behaviour, the hazard should be preliminary defined. Therefore it could be important to define other researches for each type of hazard/disaster

The computational approach was questioned due to its large effort. Before using computational models for structural analysis, a conventional building analysis shall be carried out in order to define the appropriateness of model generation and to adapt the method to the goal of the research.

Key issues

1. Identification of the hazard: It is necessary to identify first which hazard we want to approach (earthquake, wind, flood, fire, storm, ...).
2. Analysing the existing tools for evaluating the structural behaviour of traditional building systems. These tools mean the recompiling of all the work done in this field (thesis, reports, technical papers, ...). The tools also involve the evaluation of analytical and numerical approaches and the degree of detailing: limit analyses, finite element methodology, discrete element methodology, ... A multi-scale and multidisciplinary approach is necessary, to assess the material as well as the structure and building behaviour.
3. Identification of subject areas in need of research in order to develop design tools and other behavioural factors for different traditional materials and systems, such as different types of masonry and other forms of traditional construction, for which such factors are missing or inadequate for improved methodologies for the evaluation of traditional building systems.
4. Consideration of the improvement of the structural behaviour of a particular building typology and dissemination of appropriate drawings for inhabitants. These drawings should respect the field approach and traditional culture of communities.
5. Development and dissemination of appropriate guidelines for damage survey. These guide-

lines will be useful to better know the damage pattern life safety risks of a particular building type under a particular hazard, and thus be able to rationally and economically approach the repair and strengthening of such buildings in ways that augment, rather than replace their traditional structural systems.

Priorities

The research can be divided into the following items:

Building typologies

1. Identification of structural building typologies, which involves material classification (adobe, stone, fired clay brick, wood, etc), geometrical configuration (regular, irregular), construction system, number of storeys, etc. This identification can be done in different levels such as country, regional or local. There is some work done in this direction, but there is a need to build a complete literature review.
2. Specific case studies need to be carried out whenever a new building typology is assessed. A typological approach is insufficient for carrying out numerical analysis and simulation. Documentation and abstraction of the traditional typologies for the purpose of model generation have to be discussed in interdisciplinary teams, in order to meet requirements of current tools and programming aspects.
3. Identification of experimental tests performed on building typologies. On a material scale, this is necessary to have a data base of the mechanical parameters. On the building scale, experimental data is needed to validate digital modeling. Experimental testing can be done on a regional level.
4. Strategies to improve traditional structures should be designed. Those can also include the purposeful abandoning of building parts in order to save the overall building in case of hazard. The design proposals should be assessed in the same way as the existing structures.

Hazards

5. Identification of hazards (EQ, flood, fire, typhoon, cyclone, hurricane, landslide, tsunami); which should be done at a regional level.

Results

6. In order to project the scientific research to the actual building traditions, the findings should influence building codes and guidelines in the respective areas.
7. A matrix can be generated that informs about different hazards and the behaviour of different building typologies.
8. The results of the research should be readable and usable by multi-disciplinary team.
9. Further information could be generated via statistical analysis of hazard impact, number of people affected, generating a large variety of typologies, specific application interests, missing basic research, and heritage value.
10. Multi-disciplinary collaboration and networking for research within this field is necessary. It is expected to collect the approaches and share the experiences.

Group 3 : Characterization and validation analyses

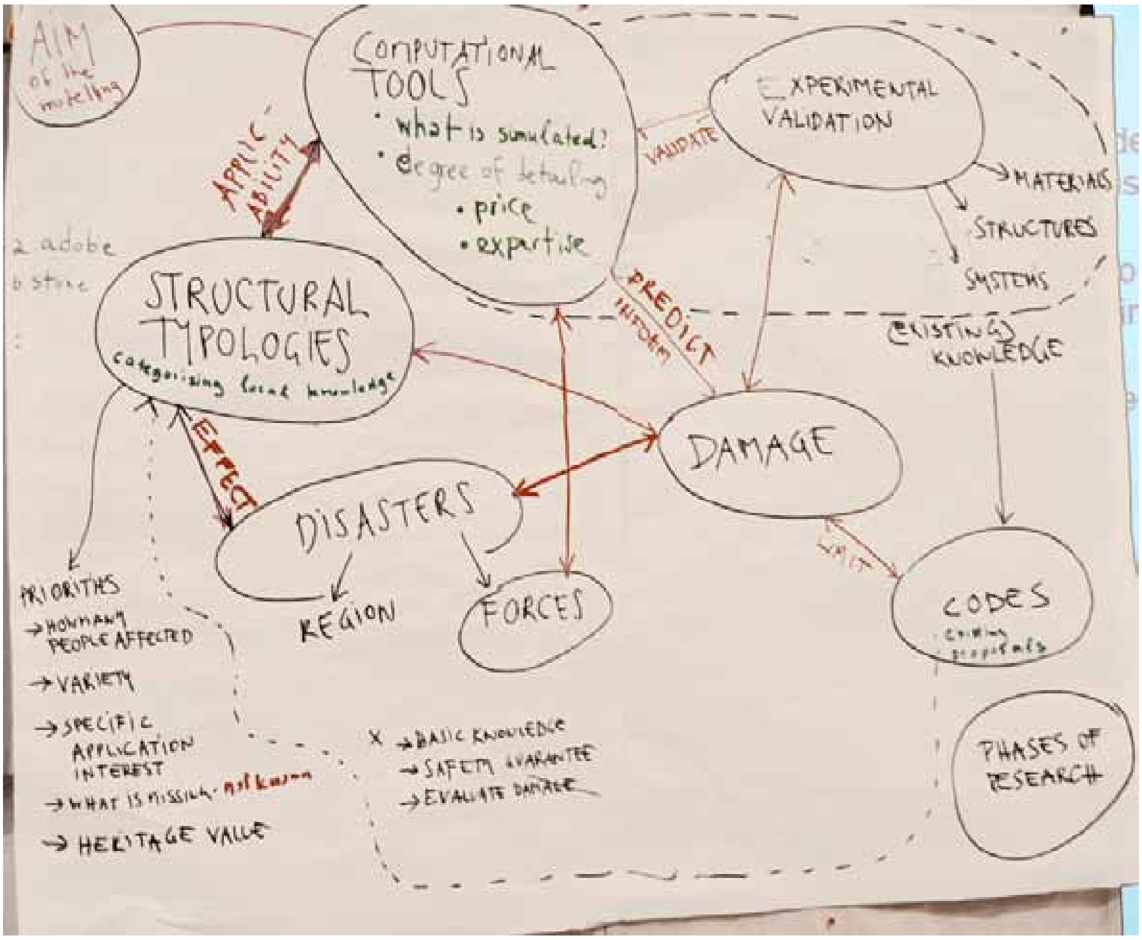


Figure 1.- Flow chart showed duting the seminar to summarize the work group.

Group 4 : Communities and drbc research

« Social Utility of Disaster-Resistant Building Cultures (DRBC) in the framework of strategies for resilience development : potentials and limitations ? » was the original title of the reflection theme. Following several discussions in which the complexity of this issue and bearing in mind the fact that many fields of social- and community-based have already been studied and discussed, we have decided to rephrase the title of the suggestion as follows :

« Communities and DBRC Research »

Objectives

Before we embark on this mental exercise we may ask ourselves: what is the « societal » aim of this approach? What is expected from these researches and from the analysis of all the results? How will it benefit the target communities (knowledges, incomes, etc.) and how are we to be sure that the objectives are suitable and are possible to achieve? A fundamental key issue :

« How do we bridge the gap between Academicians & Communities ? »

Key issues

The first key issue that has come out of discussion concerns the fact on many occasions, academicians and scholars remain confined within their own field of research. Moreover, despite the relevance of the findings, there are few opportunities to implement them. This is why we need to launch new projects to facilitate their practical implementation. Our suggestion is to make the strategic decision to view both academicians and community members as partners and the research process itself as a partnership. The method to implement would be to invite the community to become a member of the research team. Techniques of soliciting community support in research are well-defined and have been used for many years by development animators within the realm of participatory local development planning, such as « Community-driven », « Community Empowerment », etc. Hence, the following research topics come to mind :

1. Local development in disaster prone areas,
2. Research appropriation mechanisms,
3. « Time » : transitioning from « Emergency response » to « Development planning » within disaster afflicted communities.

Assessment

1. « Local development in disaster prone areas »

The actual impacts of DRBC research (& programmes) on the communities involved are often unknown mainly due to lack of information on the topic. Indeed, feedbacks are difficult to obtain and the following-up of the projects is also often forgotten or not integrated into the budgeting of pre- and post-disaster programmes. Perhaps one of the main reasons for this deficiency is plain lack of interest in this topic.

<u>Comparison of case-studies « through time »</u>

Therefore, documenting existing and past projects (of CRAterre for example) which were im-

plemented and based on local building cultures would allow us to collect information on the progress or on the decline of the programmes in course of time, focusing on their successes or failures. While not the sole case, the decades-long international experiences of CRAterre is an interesting starting point. As these projects have been carried out in various locations, in interest of saving time, this research should involve other NGOs and research centres in different countries. Furthermore the comparison of different documented case-studies (in time, location, nature of the project, etc.) will lead to a better understanding of the impacts (economical, environmental, …) of pre- and post-disasters and development programmes within a territory. It will also give us tools to establish an evaluation of the effects of the applied researches implemented with the communities.

<u>Is there a continuity in the programmes ?</u>

Another topic of interest is the matter of sustainability of our external interventions within a locality. DRBC can be perfectly adapted, can be modified, or rejected by the target communities because of different « inside » / « outside » influences and inputs. The data collected thanks to the above questions will hopefully help us to evaluate, anticipate so as to assess the possibility of :

- … the appropriation & replication of an imported technology or knowledge ?
- … the continuation/rebirth of an existing technology or knowledge ?
- … the local definition of sustainable development with hazard's factor ?

<u>As a result of the extensive documentation and analytical exercise proposed above, we will finally be able to answer the following fundamental questions:</u>

- WHEN did it occurred ? Evaluate the impact of « time-investments » and « time-use » in programmes (at which moment, by whom ?)
- WHY :
  - … would one place/community continue to use disaster resistant building cultures ?
  - … would one place/community start again to use disaster resistant building cultures ?
- WHAT are the mechanisms ? What happened when/if we loose the traditional building practices and knowledge ? What are the consequences if we don't carry them on?
- WHO was involved ?
- HOW people change their ways to build / to assure the maintenance of their buildings ?

2. « Research appropriation mechanisms » : methodologies of community mobilization within the research phase / situation analysis of building pathologies

To date, in most Disaster Risk Management (DRM) projects, communities (target groups and local authorities) have been (perhaps unwittingly) left out of any research activity envisaged by the projects. They have remained as interlocutors of questionnaires at best. They have not been called upon to take part in simple preliminary situation analysis of their status quo; the most crucial stage where communities should come to understand « why all this trouble? » and « why they should support such interventions with all their other concerns? ». « Research », as

such, has remained an academic endeavour by the very proponents of Community-Based Disaster Risk Management (CBDRM). It appears to be advisable to take inventory of community mobilization methods whereby community members are brought on board as research stakeholders.

The use of the acronym DRBC (Disaster Resistant Building Cultures) may also be misleading. The word culture implies that people are building according to disaster resistant precepts as a conviction / habit. When it is not be the case, we would like to turn it into a culture. Culture is human-centered and as such the topic of DRBC is to be grounded within communities. A disaster resistant building culture can only be arrived at through sustained activity of community members finding manifestation in the form of their active participation in research, planning and building within the local public arena.

3. « Time » :

Transitioning from « Emergency response » to « Development planning » within disaster afflicted communities

All the issues discussed in this seminar have always referred to long-term processes. However, how do we reconcile the requirements and exigencies of the emergency programmes during the post-disaster phase with the subsequent long-term and the « Development concerns ? And the everlasting concern: along with to the « development » issue, the question of the « sustainability » has also been raised. Indeed, how do we address the matter of sustainability while facing continued major risks remains at large?

We may rephrase the above concern to emphasize the « social » dimensions rather than the « process » itself : there appears to be a social discontinuity between planning for the « Emergency » and « Development » phases. Hence, with regard to this disjointed focus the following questions which deem research comes to mind :

- How does one reconcile the different concerns of planning within the two (aforementioned) phases while maintaining community support in the course of time within a participatory local development planning paradigm ?
- How does one reconcile « Social » and « Economical » dimensions of development planning ?
- What are the psycho-social impacts of rapid change within disaster afflicted communities ?

In this respect, the anchoring of « participatory active research » within long-term processes becomes really relevant for any sustainable approach. There is no need to reinvent the wheel. The knowledge base necessary to tackle the above questions exist. One can envision an overlap of CBDRM and Disaster Resistant Buildings (DRB). A partnership between « disaster resistant builders » and « development animators » appears to be a plausible first step. From a development standpoint, such concerns can be addressed in parallel to community empowerment (CE) and participatory approaches to poverty alleviation and local development planning at large. Yet one must stress that CE is a process and hence time-intensive.

In consequence, « Time » has to be considered as an important and fundamental resource on the same basis as the investment in terms of material or expertise. It could represent a crucial lever to impact on political and international aid agencies, and to influence donors and budgetary plans. Here also, the analysis and the evaluation of the case-studies comparisons will give

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us many clues and ways to improve the research. Here, we can speak about evaluating the « effects (and inputs) of target communities in DRBC researches ».

Linking of Relief, Rehabilitation & Development

Emergency shelters and post-disaster reconstruction programmes represent a significant part of the money and energy invested by international aid, without performing neither a detailed analysis of their long-term results and collateral impacts, nor a sustainability assessment. The stress should be put on more investment, research and energy in pre-disaster phases. This would be a way of linking relief, rehabilitation and development.

Conclusion

Knowing which project have failed or succeed will help us to improve the research orientations and the development of other pilot projects for the future. While CRATerre should promote research on the techniques and science of building disaster-resistant buildings in the laboratories, build in the field and locate appropriate venues to disseminate such scientific findings to both peer academia and target communities (topic of the other work groups in the seminar), it should also bring communities on board as stakeholders and members of its research activities. The aim is to achieve the understanding of :

- the social levers that foster/allow the DRBC to survive or to be implemented and replicated through time,
- the mechanisms that make DRBC responding to social needs in accordance with their evolution within a social group (what happened when/if we loose the traditional building? why should we carry on?),
- the relevance of research : what is the « societal » utility of research in such a field ?
- the mutual benefits of research on DRBC for the affected communities and vice versa.

Priorities : the ways forward

Here again, it appears to be advisable to take inventory of community mobilization methods whereby community members are brought on board as research stakeholders. CRATerre should :

- promote research on the techniques and science of building disaster-resistant buildings in the laboratories,
- build in the field and locate appropriate venues to disseminate such scientific findings to both peer academia and target communities (topic of the other work groups in the seminar),
- bring communities on board as stakeholders and members of its research activities.

Fundamental Research :

1. comparison of DRBC case-studies (projects, programmes) through time,
2. create a tool to evaluate the impact of “Time” investments » and “Time” use in pro-

grammes (at which moment, by whom ?) during the analysis of the successful or unsuccessful projects (case-studies),

3. DRBC : the qualification of a social demand ? Research program to identify the conditions for success and failure of projects based on local building cultures. To combine with the issue of :
4. risk-taking and the adequacy between the perception of risk and the DRBC,
5. the resistance to change and adaptation strategies due to the integration of DRBC in programs to reduce risk and vulnerability

The concept of «development» and «local capital» : research and development in the study of physical and social vulnerabilities and resilience applied to DRBC (crossing tools and methodologies from the social sciences and engineering),

Towards « blended » approaches? Foster research and experimentation in ecological, economical and responsible disaster-resistant habitat (prototypes) : study of the parameters of the building in relation to its social and environmental objectives (integrate the global (climatic) trends and the knock-on effects) in very economical materials

We (participants to the seminar) may want to develop a common tool to evaluate the research priorities among ourselves.

<u>Applied Research :</u>

1. Activities :

- Local development in disaster prone areas
  - inventory of the local building cultures,
  - improvement of the quality control of structural elements for post disaster (re) construction in the field,
  - analysis of the local mainstream development policy,
- Research appropriation mechanisms
  - diagnosis of the pathologies post-disaster – data requirements
  - classification of building cultures according to their level of resilience
  - redaction of beginner's books to build back better
- Time : from « Emergency response » to « Development planning »
  - development of partnerships between « disaster resistant builders » and « development animators »
  - support to more investment, research and energy in pre-disaster phases in order to linking relief, rehabilitation and development.

<u>Dissemination / Diffusion / Teaching</u>

1. the hazards involved : enhance the image of DRBC towards local populations and decision makers.
2. the use of local knowledge : supporting the development of qualifications and rules of « best practice » with the main local building materials and their use for disaster-resistant construction.
3. Disaster-Resistant Building Cultures (DRBC) : strengthen and support a work exchange between each continent / country involved about the building technologies and materials definitions, in order to develop a more comprehensive taxonomy of their meanings.
4. Incorporation of “participatory development facilitation / animation” within university curricula.

Group 5 : Terms and methodologies

Assessment :

The aim of the group was to share on how to help a better link between field activities and scientific approach. How to acquire a common language and a common culture within various stakeholders involved. The group worked mainly on how existing research results can benefit to actors who will implement field activities. Aim is to help the communities to (re)appropriate themselves the research results. The group shared also on how monitoring of project during their implementation can also be a field of research.

- As a first assessment, the group emphases on the need to look at any field situation within an integrated approach. There is a risk if only specialist will be involved in analyzing a context (cf. Ferruccio Ferrigni). Each assessment should be a synthesis done by a "generalist" of results of specialist's analysis.
- A second recommendation, because any local building culture is very contextual, is that research should more focus on developing "methodological approach" than "technical solution".
- Finally, a third recommendation, when the objective of field activities is to improve local population resilience, is to take care to avoid trying to preserve local building culture only for itself. To have any chance of success to preserve a local building culture, it seems that this one should have a clear added value to the local existing situation. And, if possible, should be economically profitable at very short term, to potential users.

Group work results:

First of all, the group assess that there is a lot of public that should be addressed to disseminate the research results. For all of them, specific tools and support should be developed. The group list a number of potential public (local communities, local / national / International authorities, Professional, Academic / Donors, etc…). This list is not exhaustive.

Regarding strategies, the group insists on the fact that, if "pilot project" will be implemented to do research / action in the group theme, both Post and Pre disaster zone should be considered. It will be a plus if such pilot project may be implemented in geographical areas where local stakeholders will be interested by the outcome of such research

Group proposed activities:

Many local researches exist in disaster prone areas. But these works did not benefit for an international recognition. It may be a plus if our networks identify, then valorize research done in local context.

For a better dissemination of research results, it is recommended that research outcomes will be translated in training modules, this for different publics.

When talking about research / action, it is highly recommended to involve, since the beginning, local key actors that can carry on with research development, as well as benefit of research results in projects they are implementing.

We also do strongly recommend to be able to popularize research outcomes in order to be sure these results will be available for the field actors.

There is also a recommendation regarding the need to value local building culture. This could be achieved through scientific publication on local knowledge topics related to current relevant issues (Resilience, Global warming, Participatory approach, Economical Impact, etc…). It could be of interest to focus on "small risk", very often forgotten, but if added one to each other, who have much more impact every years than big disaster occurring one's every 10 years.

Group Priority recommendations:

1. To promote research / action with key local partners involved

To propose a topic for a PhD thesis:

- How to help the local community to reappropriate itself with its own building culture in a critical and progressive manner through participatory-driven approaches.
- Case studies based on field projects to draw methodological guidelines in an integrated approach. Selection of projects related to different contexts, situations, in or not in risk-prone areas, pre or post-disaster.
- The aim of the research project is to identify and develop methodological tools useful for the actors in the field.

Remark : it could be different theses from different institutes in different context to have a broader approach.

2. To popularize research outcomes

Research outcomes popularization strategies:

- Use and limits of calculation models to validate vernacular building techniques,
- Relevant methodologies resulting from existing PhD researches on the subject, that could have an impact on field actors practices linked to local building cultures.

These strategies could be popularized and disseminated, as for example through:

- sensitization materials to raise awareness on the approach related to the developed methodology,
- guidelines and handbooks,
- training modules to be implemented on the field as well as part of training provided by institutes (such as universities, NGO, etc).

These different tools should be adapted to different publics (project officers, field officers, technicians, decision-makers, etc).

Illustration 7- research work presentation (Credit : Mauricio CORBA BARRETO)

2- CONTRIBUTORS’ PAPERS

Title : The contribution of Archaeoseismicity to the knowledge of traditional hazard resistant constructions

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Abstract :

Archaeoseismology is a multidisciplinary field of research, which object is a better understanding of communities comportments in front of natural hazards, especially earthquakes. The knowledge of the traditional resistant construction technics, the means of buildings repair and reinforcement after earthquake complete the objects of this field. These researches are also one of the hazard evaluation mean, completing the improve of historical seismicity, and seismic records.

Concerning the hazard resistant construction technics we will present here a short history of the field and some results of our researches. At first in Minoan Crete Greece during the Bronze Age, where the antiseismic standards are used at all the level of the buildings and the town organization for a better resistance. But also in Manosque France, where, the archaeological reading of the town historical buildings permit us to give a better evaluation of earthquakes recurrence.

The contribution of Archaeoseismicity to the knowledge of traditional hazard resistant constructions

Introduction

Speaking about archaeoseismicity, for those who didn't know this discipline, three questions can be asked: What is it? For what contribution? In what context? Archaeoseismology is a multidisciplinary field of research, it is one of the four methods used to evaluate the seismic hazard, in complement of the seismic records, the historical seismicity, the palaeoseismicity. The contribution of archaeoseismicity concern different subjects :

- the recognition of the traditional hazard resistant constructions (the CUEBC local seismic cultures (FERRIGNI & al, 1989 ; POURSOULIS, 2000, 2003) ; and also the recognition of preventive or reinforcement technics (FERRIGNI & al, 1989),
- the research of past earthquake traces on many objects from Antiquity until contemporary times (POURSOULIS & al, 2006 ; POURSOULIS, 2009a).

The context in which archaeoseismology can be applied is naturally that of research projects for a better understanding of the hazard impact on a area, but also after a recent earthquake in post-seismic missions like the one of L'Aquila in 2009, where we provide information about the architectural evolution of the town, and the impact of past earthquakes on this one, we recognised some past earthquakes traces and post-seismic repairs (POURSOULIS, 2009a, 2012).

1. To recognise the disaster resistant construction techniques

- The Bronze Age Crete

- *The seismic context*

The island of Crete is located just upon the Aegean arc subduction zone the place where are generated superficial and intermediate earthquakes. For this reason the tectonic movements play an important part in the geological constitution of the island in two ways:

- at regional level, there is a majority of subduction earthquakes happened a long the numerous active faults with regional propagation area (fig. 1). There is also a double uplift movement of the island from south to north and from west to east,
- at local level, the island's face

Figure 1 : Aegean arc subduction zone (ANGELIER, 1977)

mountainous with three important reliefs taking the major part of the territory. These mountains are cut by an important fault network.

This tectonic situation produced three seismic specificities. The island of Crete presents a seismicity mainly local, moderate and recurrent. Local, because on the 135 earthquakes recorded by the National Observatory of Athens (NOA) from 1913 until 1935, 103 happened along the fault network of Crete. Moderate, because the intensities of these earthquakes go from I to IV on the Rossi Forell scale, those used at the records time. It is recurrent, because the same places are mainly affected. It relates to the town of Heraklion with 46 earthquakes, the town

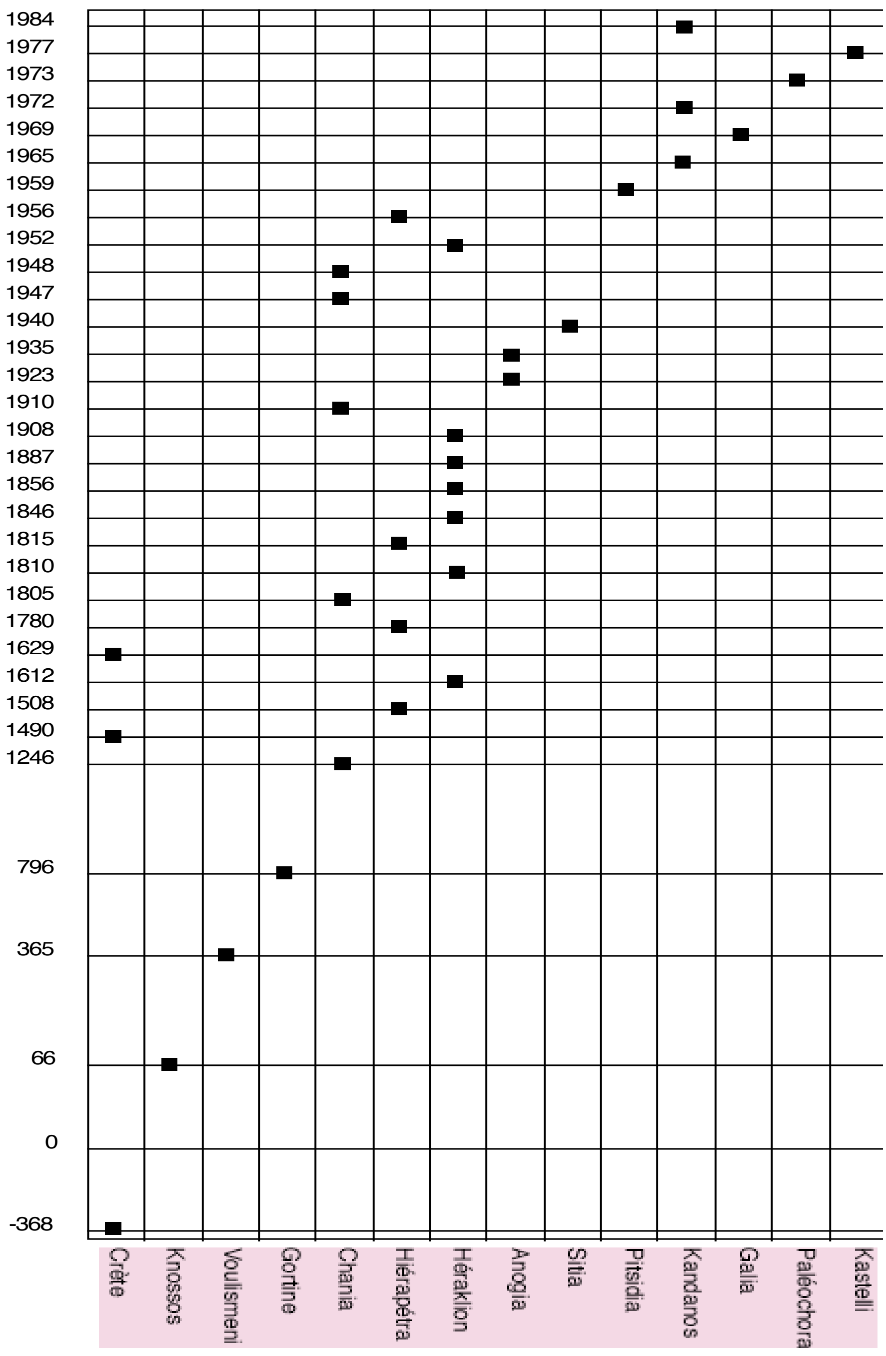

Figure 2 : graph of the seismic recurrence in Crete (POURSOULIS, 1999)

of Hierapetra with 46 earthquakes too, the town of Chania with 22 earthquakes (fig. 2). Records and seismic catalogues show that violent earthquakes happened every 100 to 500 years.

- *The historical context*

The occupation of the island is attested from Neolithic period (fig. 3), right from this period an important part of the settlements are organised in very sophisticated villages. After the Neolithic come the Bronze Age period during which take place the Minoan civilisation.

Date (BC)	*Époque*	*Principaux événements*
7000-6500	*Néolithique Acéramique*	*1ere occupation à Cnossos*
6500-5700	*Néolithique Ancien*	*1ère occup. à Palaikastro et Phaestos, nombreux habitats en grottes à Epano Archanes*
5700-4700	*Néolithique Moyen*	
4700-3250	*Néolithique Récent*	*1ere occupation de la plaine du Lassithi*
3250-2500	*Minoen Ancien I*	*1ere occupation à Kato Zakros, Gournia*
2500-2300	*Minoen Ancien II*	*1ere occupation à Myrtos Pyrgos et Phournou Korifi*
2300-2100	*Minoen Ancien III*	*1ere occupation à Malia, Vassiliki et Tylissos*
2100-1900	*Minoen Moyen IA*	
Début des échanges avec l'est de la Méditerranée		
Construction des palais de Phaistos, Malia et Knossos		
Multiplication des habitats sur l'ensemble de la Crète		
1900-1800	*Minoen Moyen IB*	
1800-1700	*Minoen Moyen II*	
1630-1628 date de l'éruption de Théra selon les analyses physico-chimiques		
1700-1600	*Minoen Moyen III*	
Transformation des palais et de quelques bâtiments ordinaires pour utiliser le nouveau plan découpé en îlots dynamiques		
Construction du palais de Kato Zakros		
Linéaire A utilisé à Cnossos		
1600-1500	*Minoen Récent IA*	*Transformations au palais de Kato Zakros*
1500!: date de l'éruption de Théra selon la céramique trouvée à Akrotiri		
1500-1450	*Minoen Récent IB*	*Autour de 1450 les trois palais de Malia, Phaistos et Zakros ont été incendiés et abandonnés*
L'occupation en Crète est à son plus haut niveau vers 1500 BC		
Multiplication des habitats sur tous les sites occupés avec une forte concentration autour de Cnossos		
1450-1400	*Minoen Récent II*	*Phase très fortement associée au MRIB et peut ne faire qu'un avec elle*
1400-1350	*Minoen Récent IIIA1*	*Incendie de la partie Est de la Maison E à Malia*
1350-1300	*Minoen Récent IIIA2*	
Apparition du Linéaire B sur tablettes d'argile, incendie à Cnossos		
1300-1200	*Minoen Récent IIIB*	*Quelques murs grossièrement construits apparaissent à Phaistos, construction du bâtiment oblique à Malia, construction grossière ds la partie Est de la Maison E de Malia, diminution du nbre d'habitats occupés sur l'ensemble de l'île, sauf à Epano Archanès où l'occupation continue. L'occupation se poursuit dans la partie Est du palais de Cnossos après l'incendie et l'apparition des Mycéniens en Crète*
1200-1050	*Minoen Récent IIIC*	*Période de Crise, effondrement de l'occupation, Cnossos continue de fonctionner mais c'est la fin de son pouvoir. Apparition des premières incinérations à Malia dans la Maison E (éléments étrangers d'origine Mycénienne)*

Figure 3 : chronological table of proto--historic periods (POURSOULIS, 2003)

This civilisation will dominate the Mediterranean basin all along this period with many commercial contacts through all the Europe, Africa, Middle East and Minor Asia. The development of the Minoan society and the fructuous commercial exchanges with the Mediterranean area generated many economical and political transformations inside the organisation of the territory (POURSOULIS, 1999). The construction of the Palaces, administrative places each one in charge of a region, managing production and distribution of all the commodities and foodstuff for their territory will be the occasion for the first technical innovations in construction. After that, constructive innovations, especially in 1700 BC, will be regularly devised and the constructions, palaces at first but also particular houses, will be adapted in order to use them (POURSOULIS, 2009b).

- The evolution of Minoan Architecture

Right the Neolithic period and the first villages, the architectural type of constructions is that of complex houses (TREUIL, 1983), buildings of quadrangular form with at least three rooms which indicate a specification of the leaving space (fig. 4a).

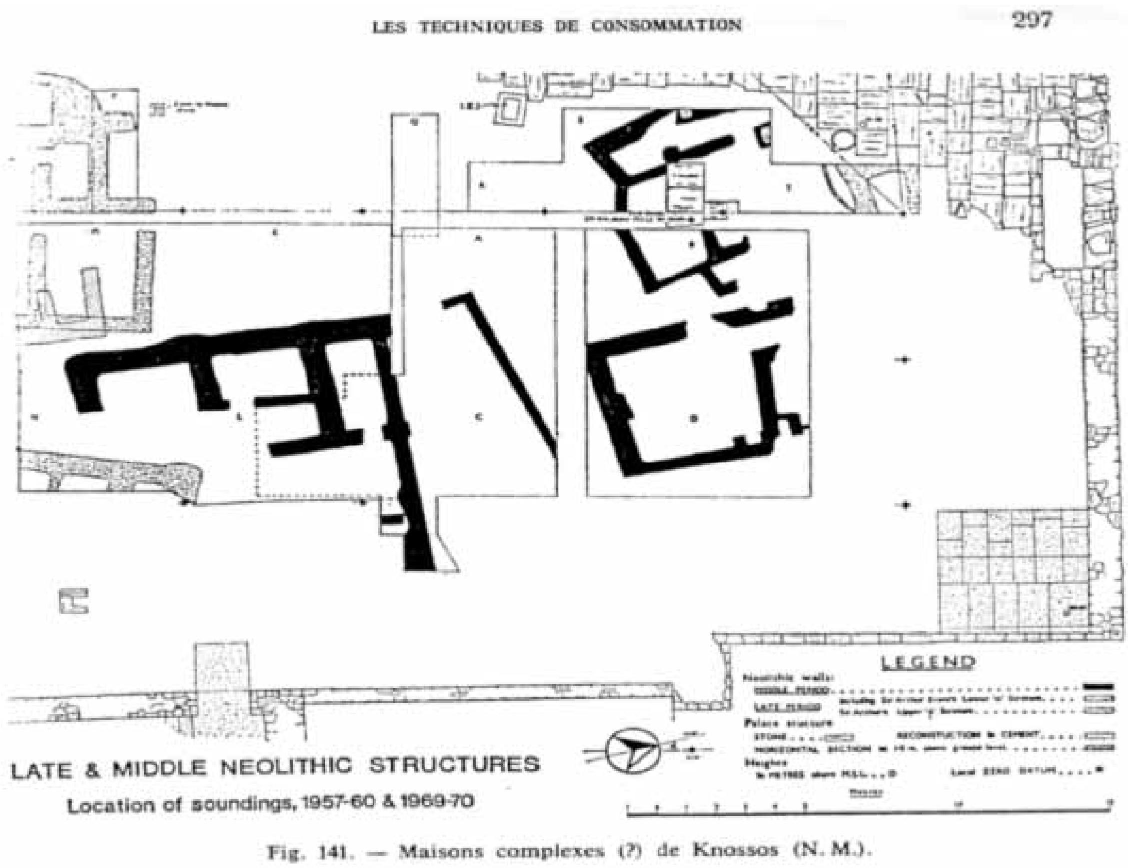

Figure 4a : Neolithic houses at Knossos (TREUIL, 1983)

Figure 4b : Plan of Myrtos Phournou Korifi town (WARREN, 1972)

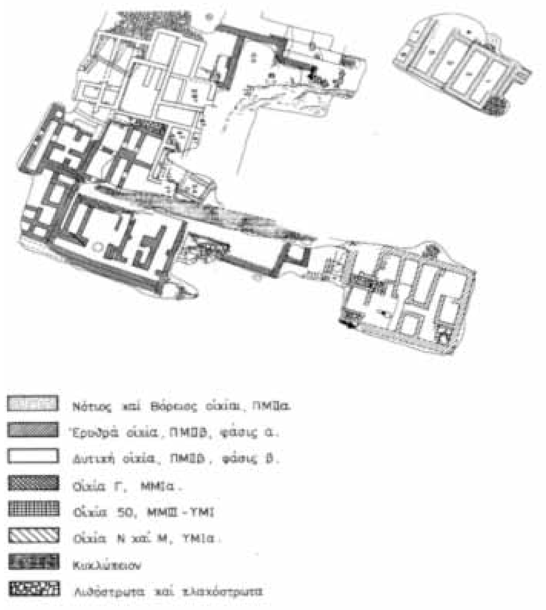

Figure 4c : plan of Vassiliki town (ZOÏS)

During the Old Minoan period (MAI-II 3250 -2300 BC), two types of complex houses co-exist: the agglutinated shape with houses and rooms disposed side by side without identification and organisation (fig. 4b). The other shape is organised, with individualised houses separated from each other, in which the room are regularly disposed and functionally segregated (fig. 4c).

- A local seismic culture

In traditional societies, the conception of seismo-resistant construction techniques is the results of experimentations made after every significant event.

There is an evolution in the way of construction and the knowledge accumulated by these experimentations and efficient technics validated by the confrontation with the earthquakes are transmitted to the next generations, when earthquake's recurrence permit it. That is a local seismic culture.

There is three important points in seismic areas :

- to choose a compact and solid soil,
- to use resistant construction techniques,
- to maintain the building in order to suppress vulnerability.

The shape of Minoan buildings is regular, rectangular or square with a central court in the case of the palaces. As we will see, every part of the building is an answer to the seismic problem and match with the now anti-seismic rules.

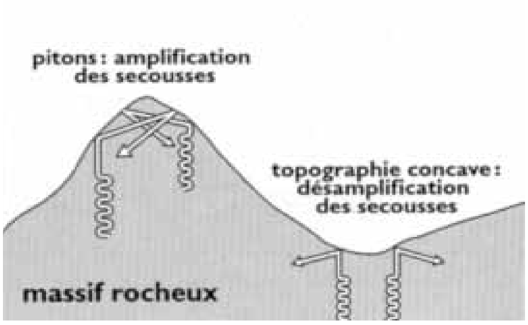

Figure 5a : topographic site effects (ZACEK, 1996)

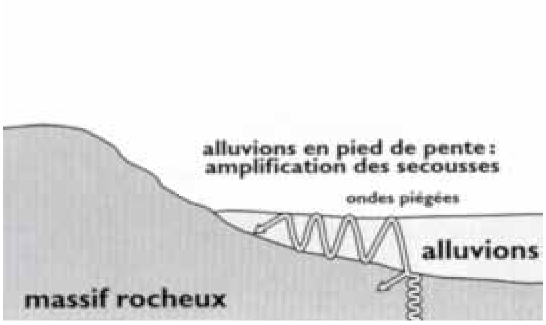

Figure 5b : sedimentary site effects (ZACEK, 1996)

Figure 5c : rock site at slope of the hill for Macryallos settlement implantation (POURSOULIS, 1999)

- The Minoan resistant construction techniques

The Minoan settlements are located on solid and compact soil (calcareous rocks) at the slope of the hills, which is better than top location because of the site effect (fig. 5a, b, c). The type of buildings foundations are choose according to the depth of the bedrock.

We found 3 types of foundations :

- no foundation, just rock cut anchorage,
- superficial foundations (fig. 6b),
- depth foundations.

At the palace of Phaistos we found rock cut anchorage where the bed-rock is on surface (fig. 6a). Superficial foundations, like sole foundation were used at Phaistos palace where the bed-rock is at small depth: just 23cm under surface soil at the west wing (fig. 6b, c).

Figure 6a : rock cut anchorage at Phaistos Palace (POURSOULIS, 1999)

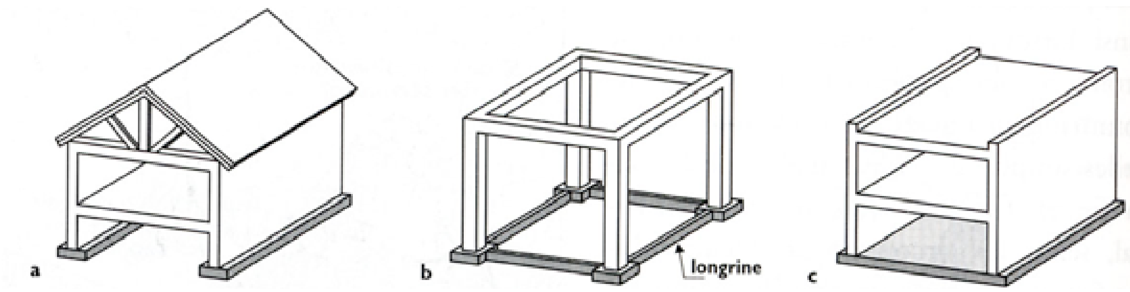

Figure 6b : superficial foundation types (ZACEK, 1996)

Figure 6c : sole foundation at Phaistos Palace (POURSOULIS, 1999)

Two types of depth foundations are experimented in Minoan time: at Knossos palace, the north wing was establish upon depth foundation like build tells of 7m depth to found the bed-rock (fig. 7a, b). At Phaistos palace, the west wing was established upon

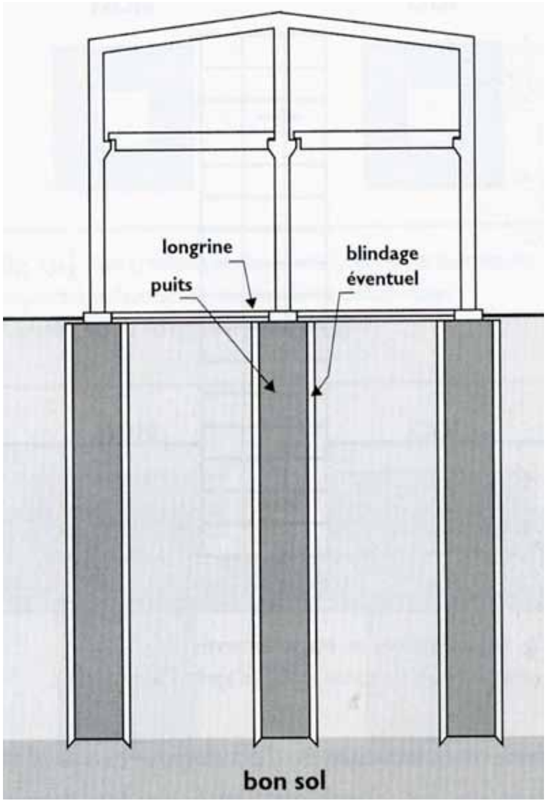

Figure 7a : wells for depth foundation (ZACEK, 1996)

Figure 7b : 7m depth built well for north wing foundation at Knossos palace (EVANS, 1928)

Figure 8a : buried floors for depth foundations (ZACEK, 1996)

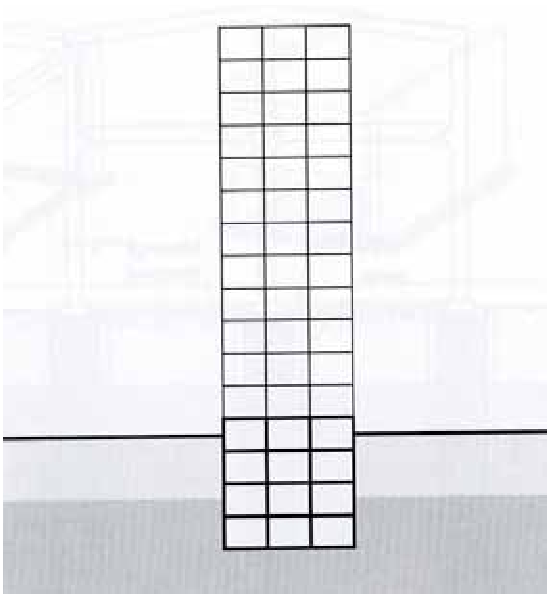

Figure 8b : buried floors for west wing foundation at Phaistos palace (LEVI, 1976)

buried floors (fig. 8a, b). The building walls are made of two facings, which are tied by wood beams (fig. 9a, b) and the superstructure was made of a tri-dimensional wood-frame (fig. 10). The evolution of the techniques started with the introduction of cut stones in 1900 BC, for

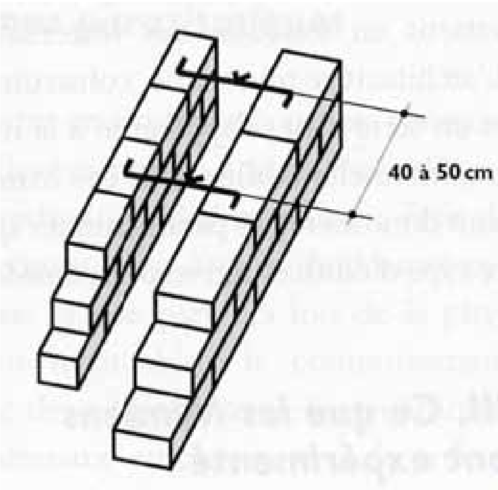

Figure 9a : double facing walls tied with metallic ties (ZACEK, 1996)

Figure 9b : double facing wall tied with wood beams at Knossos Palace (EVANS, 1928)

Figure 10 : wood-frame in a wall at Knossos palace (EVANS, 1928)

the construction of the palaces, which give a better resistance to the structure than the rubble stones. After that in 1700-1600 BC another technical innovation was introduced: the symmetrical plan divided in dynamic blocs. To apply this innovation the existing buildings were modified (fig. 11a, b) and the new buildings were constructed in 1700 BC directly with this new shape (fig. 12).

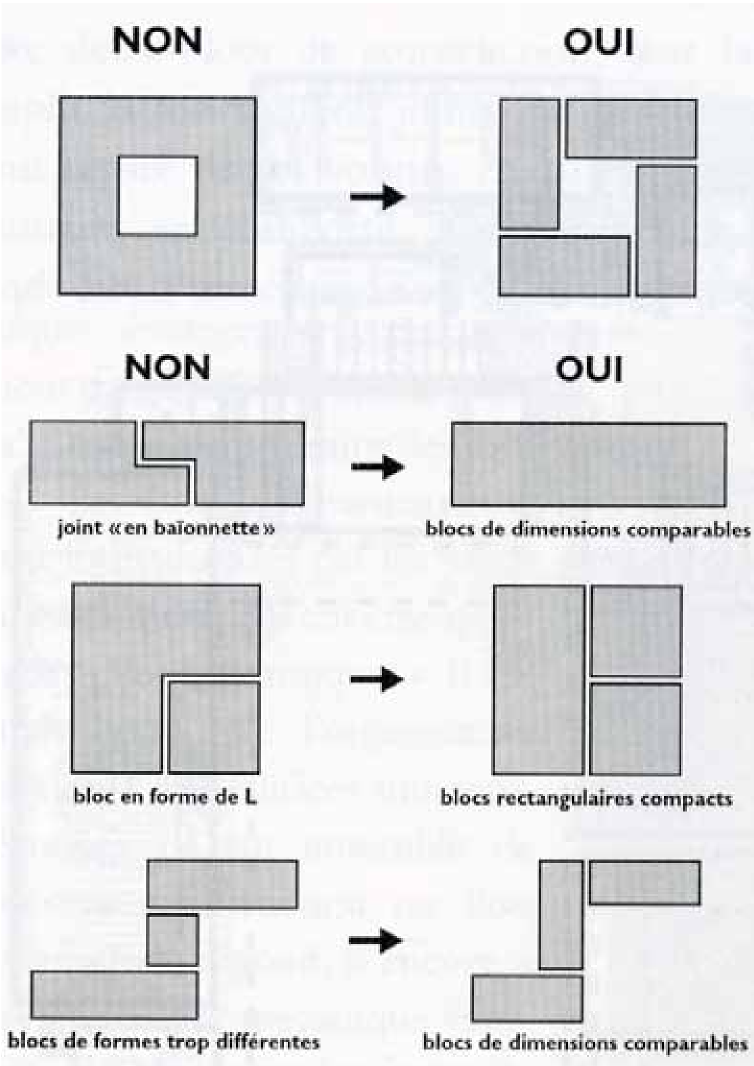

Figure 11a: antiseismic rules for building blocs division (ZACEK, 1996)

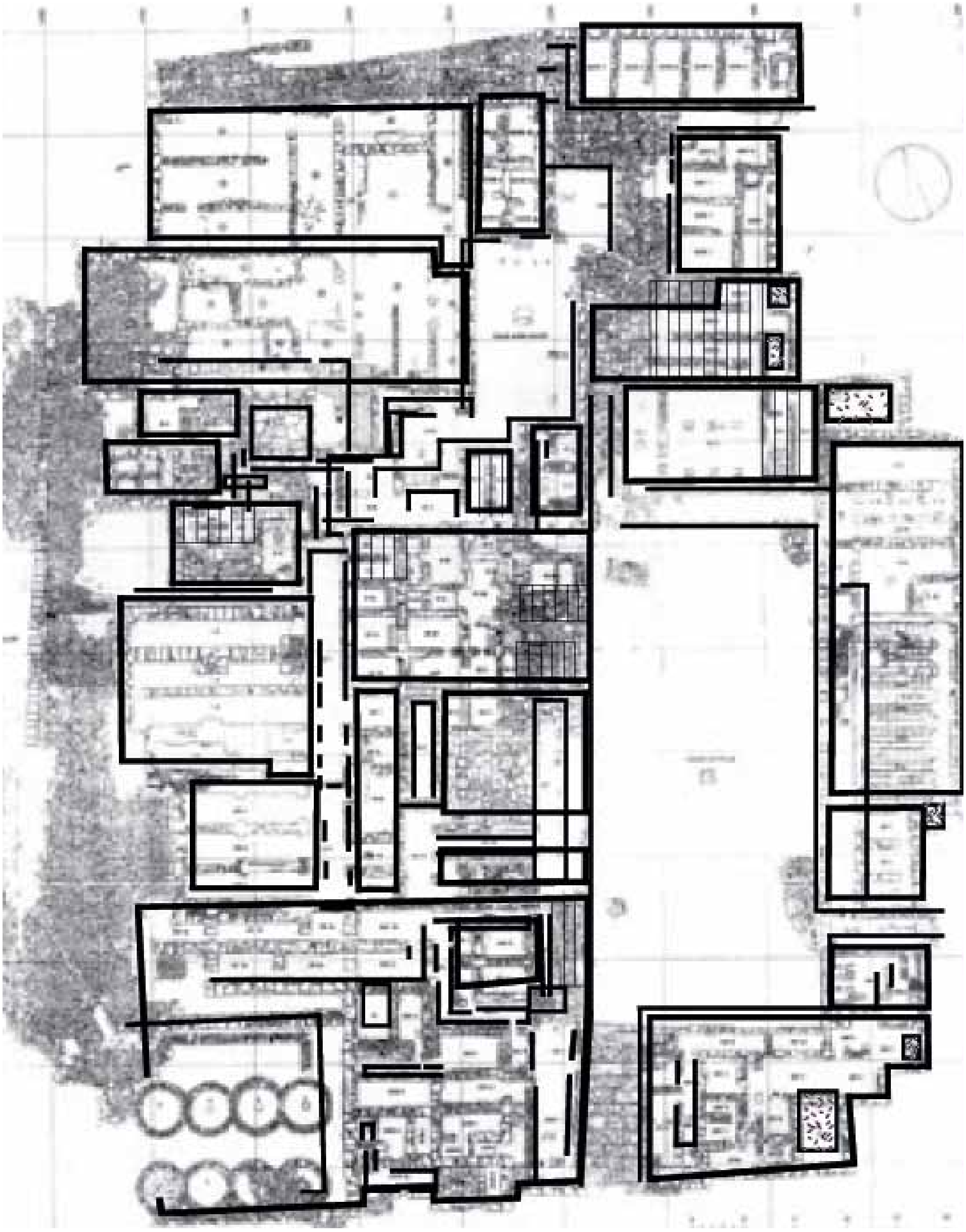

Figure 11b: dynamic blocs at Malia palace (POURSOULIS, 1999)

Figure 12: plan of Da house built directly in dynamic blocs in 1700 BC (DEMARGNE, GALET DE SANTERRE, 1953)

Figure 13: plan of the Zakros town dived in dynamic blocs (POURSOULIS, 1999)

2. The research of past-earthquakes traces

- The 1708 Manosque Earthquake: earthquake intensity revised

- The seismic context

The town of Manosque is located south-east of France in the region of Provence. In this part of the territory there is an important fault segment of the Moyenne Durance Fault and Manosque is situated just upon one part of this Fault (fig. 14).

We know by historical seismicity that earthquakes happened in Manosque every 100 years : 1509, 1601, 1708, 1812, 1913. The earthquake of 1601 was a bit problematic, any assurance that it had affected the town. The archaeoseismological researches on the town buildings permit to find some traces and to comfort the periodicity.

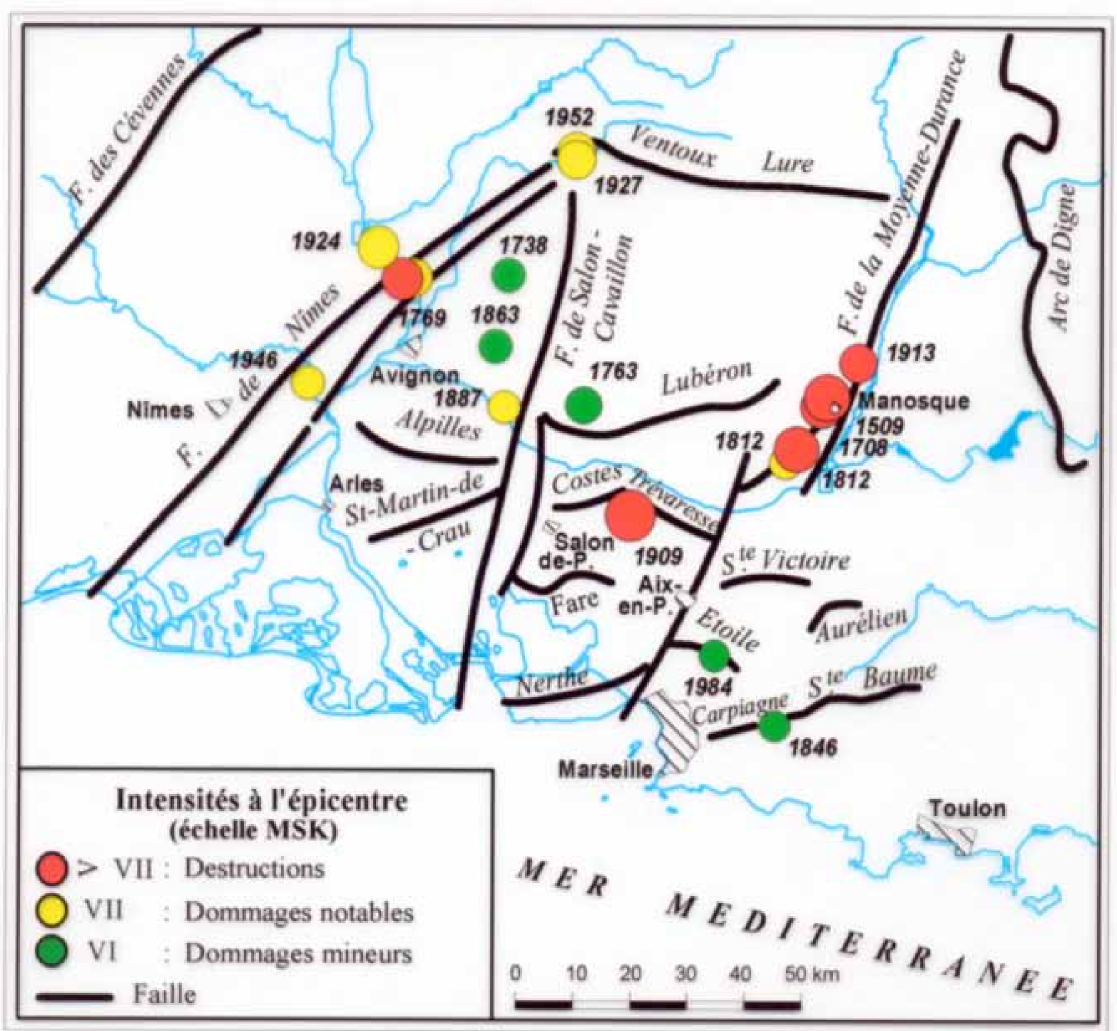

Figure 14 : map of the Moyenne Durance Fault (IRSN)

Theme 1 : Historical and archaeological approaches

Figure 15 : map of the 1708 earthquake area intervention (POURSOULIS, 2003)

The research of traces in the surrounding of Manosque, permit us to establish the intervention area of the 1708 earthquake, affecting the town and 13 villages around (fig. 15). Archaeoseismology needs a multidiciplinary way of researches using informations from :

- geological and seismological context,
- historical documents describing the event and its effects,
- architectural styles and construction techniques knowledge, in order to define the chronological boundaries in which the traces must be researched,
- engineering knowledge in order to have an idea of the wreck mechanism and the building comportment during earthquake,
- seismic effects, reinforcement and rebuild methods,
- the archaeological reading of the buildings in order to recognise, identify in Stratigraphic Units, and record, all the events affecting a building during its life.

An example of archaeological reading is presented here with the chapel Ste Agathe in the village of St Maime, situated North of Manosque, in the earthquake intervention area. This example presents the 9 Stratigraphic Units we recognised in the west and south walls of the building (fig. 16). In this chapel, we found the traces of 1708 earthquake effects: the sloping down of the hill west of the building, leading to the closure of the front door with necessity to open an other one in the south wall in 1745.

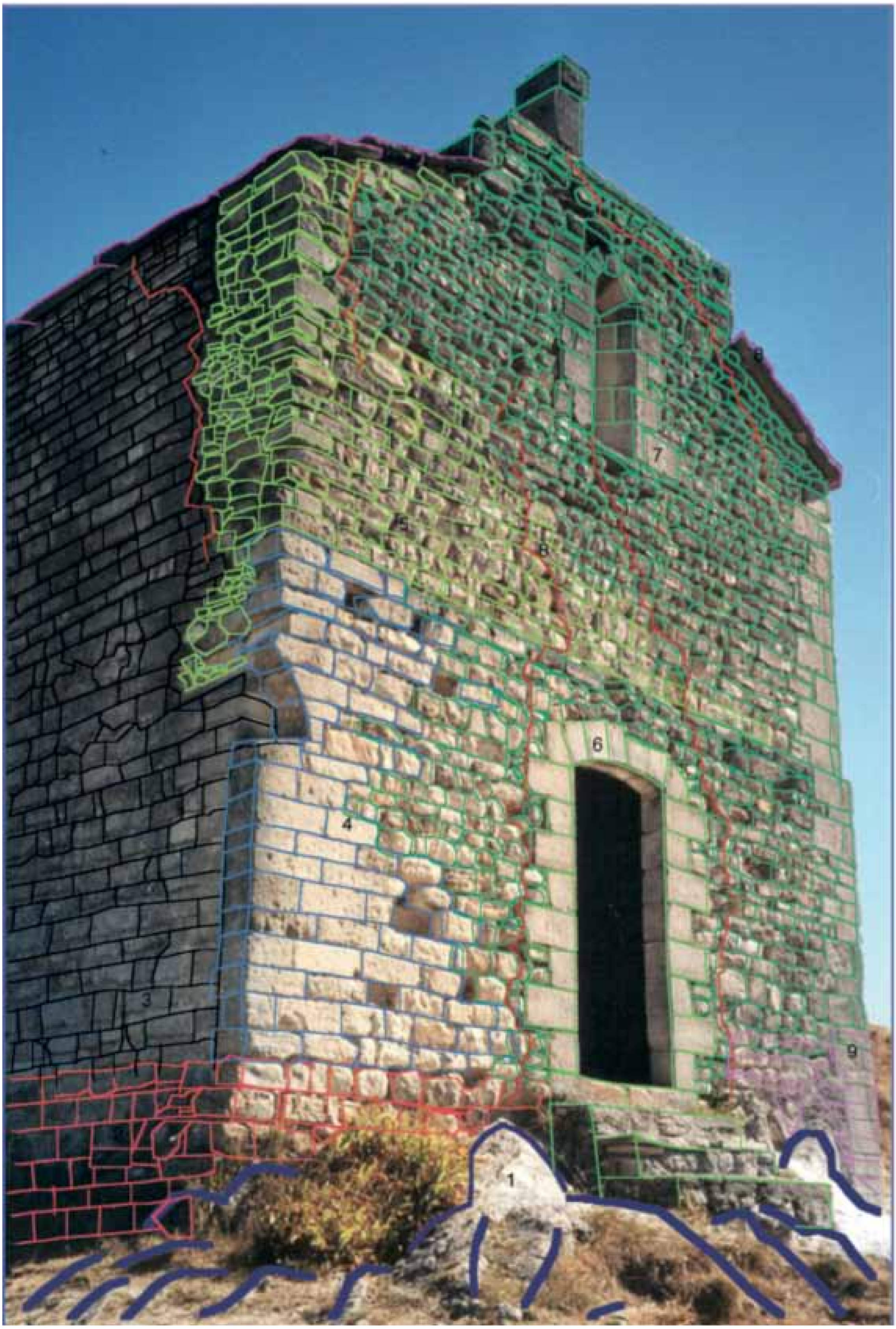

Figure 16 : Ste Agathe Chapel showing the 9 SU (POURSOULIS, 2003)

The church of St Sauveur in Manosque was a good recorder of earthquakes happened in the town. We found the traces of all of them from 1509 to 1913 and we identify every Stratigraphic Units composing its history. A synthetic way to present these Units is a diagram of Harris as shown here (fig. 17). In this diagram, the red circles identify all the earthquakes happened in Manosque which traces are found in the building evolution.

3. Post seismic missions

- L'Aquila: the contribution of archaeoseismology

After the earthquake of 2009 which affected strongly the historical town of L'Aquila, the French ministry mandated the AFPS (French Association for Antiseismic Engineering), in order to recognise the seismic effects, to understand the conception problems and to draw the lessons for the French historical

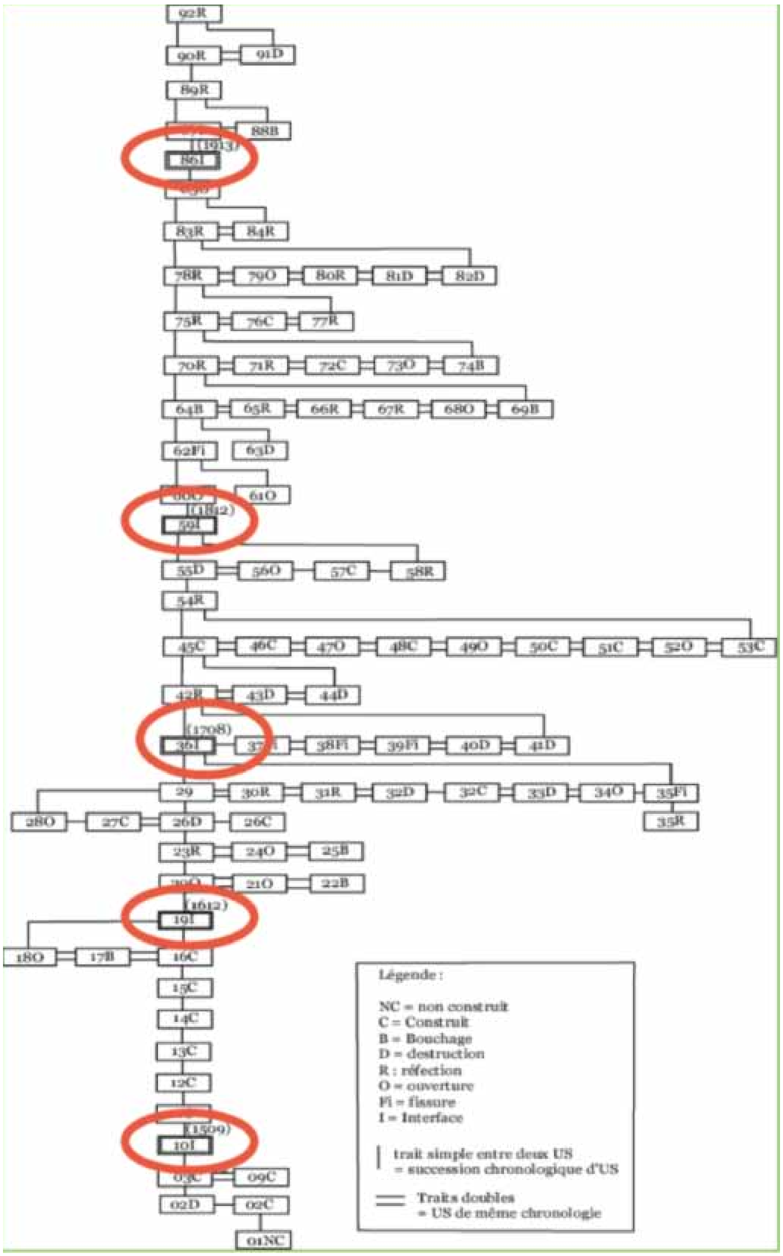

Figure 17 : diagram of Harris showing the SU of St Sauveur church in Manosque, the red circle identify the earthquake events (POURSOULIS, 2003)

buildings. As a specialist of historical buildings I was a member of the experts team who go in L'Aquila. The town of L'Aquila was affected by 5 big earthquakes during historical times, after INGV information, that of : 1315, 1349, 1461, 1703 et 1915. The architecture of the town was very rich in all the styles from roman to contemporary one. Some style modifications could be the direct consequences of earthquake intervention, people taking the event as a pretext for building improvement. Some seismic historical repairs are recognized in the town (POURSOULIS, 2012).

Figure 18a : the 17th century building's pillar repair (POURSOULIS, 2009a)

Figure 18b : wreck mechanism of composed flexion on a pillar in 2009 earthquake in L'Aquila (POURSOULIS, 2009a)

Figure 19: two different types of tie rods on a 15th century building's angle (POURSOULIS, 2009a)

- Post seismic repairs with clips

In a building of 17th century (Baroque style), presents a pillar repaired with metallic clips (fig. 18a). The wreck mechanism is probably a bursting under compound flexion (fig. 18b). According to the building date, the repair could be considered as an effect of the 1703 earthquake.

- Insert of tie rods in the angles and floor levels

Another type of repair is the insert of tie rods in the angles or floor level in order to maintain together the facing walls and floors. These measures are often take after an earthquake in order to increase the building resistance. In a 15th century building we found two different types of tie rods in an angle, showing two consecutive repair, probably after the 1461 and 1703 earthquakes according to the building's date (fig. 19).

- Identification of part-earthquake traces

During an archaeological excavation in 2008, some elements revealed the intervention of a past earthquake in a villa near the theatre of Amiternum out of L'Aquila.

A stone pavement was broken and displaced probably after a soil movement, perhaps an earthquake (fig. 20). Other traces of past earthquakes are recognised on buildings in L'Aquila and in the surrounding villages.

Figure 20: broken pavement in Amiternum villa (archaeological excavation, POUSOULIS, 2008)

Conclusion

Achaeoseismology is a multidisciplinary way of investigation, which objects are:

- the research of past earthquake traces in archaeological sites but also on historical buildings by the archaeological reading,
- The identification of hazard resistant construction technics in ancient or traditional societies,
- It could be efficiently used in many contexts: research programmes, post-seismic mission, excavation and prospection situations.
- It offers a complement to geological, historical, and earthquake recording data for a better understanding of seismic comportment and intensity evaluation.

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Title: SEISMIC-V | Vernacular Seismic Culture in Portugal

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Country: Portugal

Abstract:

SEISMIC-V is a research project coordinated by the Architecture & Heritage Research line of CI- ESG, Research Center at Escola Superior Gallaecia. The project will be developed during two years (2013-2015) with the partnership of the Departments of Engineering of the University of Aveiro and the University of Minho. SEISMIC-V was funded in the framework of a very demanding national research competition program, from FCT-Portuguese Foundation for Science and Technology. According to the President of FCT, the rate of funded research projects was 13% and SEISMIC-V was the only research project from a private university funded by FCT.

The most memorable and deadly earthquakes in Portugal's recent history occurred in 1755, 1909, 1969 and 1980. Although Portugal has been identified as a moderate-risk country relative to its vulnerability to earthquakes, the fact remains that it is susceptible to earthquake occurrence and damage in the future. Given this fact, the broad question of the research interest became: What did the local populations do to repair and restore the buildings where they were living? The research will address the query related with the identification of seismic resistant architecture elements that can be identified in the in-use vernacular heritage. It will also respond to the question if 'Local Seismic Culture' (LSC) can be consistently identified in Portugal.

The project findings will become a helpful instrument to identify seismic resistant features used in the past to respond to earthquakes; and traditional techniques and architectural elements applied related to safety standard.

SEISMIC-V intends to fill the gap regarding this critical research problem. The research will contribute to the awareness and protection of the local seismic culture. The project results will provide data for the strengthening of seismic-resistant architectural components in the in-use vernacular heritage, which in case of earthquake can save lives.

SEISMIC-V | Vernacular Seismic Culture in Portugal

In spite of being identified as a moderate-risk country regarding its vulnerability to earthquakes, there were memorable and deadly earthquakes in Portugal's recent history. When addressing the literature review several deadly earthquakes are identified, for instance, in 1755, 1909, 1969, and 1980 (L.N.E.C., 1986 ; SOUSA MOREIRA, 1991). The fact is that earthquakes are susceptible to occur and to kill population through damage of the in-use vernacular architecture. The research of vernacular seismic culture in Portugal is therefore relevant, so as to save lives through risk prevention mitigation. SEISMIC-V intends to fill the gap regarding this critical research problem. The project will be therefore responding, to one of the principal recommendations published by TERRA 2012 Advisory Committee (PUCP, 2012), during the international conference TERRA2012 organized in Peru, by PUCP, with the support of ICOMOS and UNESCO. An important recall on this matter had been already addressed during the international conference SismoAdobe2005 (SismoAdobe, 2005).

Therefore, a sound research on the identification of seismic resistant features in Portuguese vernacular architecture and the methodological tracing of a Portuguese Local Seismic Culture still needs to be addressed. The literature review on seismic resistant Portuguese architecture reveals that most of the studies have been focused either in the seismic resistant Pombalino construction (LOPES DOS SANTOS, 1994 ; MASCARENHAS, 1994), either in architectural heritage (GECoRPA, 2000)) or urban housing (L.N.E.C., 1982), but very little related to local seismic culture (FERRIGNI, 1990 ; CORREIA & MERTEN, 2001).

The main research questions to be addressed through the project would be: what did local populations do, following an earthquake, to repair and restore the buildings where they were living? How did local populations prevent buildings to fall under an earthquake occurrence? Are these seismic resistant features in vernacular architecture still playing an active role to dissipate energy in case of earthquake occurrence?

The research will address a critical gap in knowledge regarding vernacular architecture earthquake preparedness. The fact remains that Local Seismic Culture (LSC) research in vernacular architecture has had little attention by the Architecture and Engineering scientific communities. This research is based on the fact that vernacular architecture is an outstanding inheritance, from which remarkable solutions can be obtained and reinforced.

The long-term goal of SEISMIC-V is to contribute to the awareness of LSC, but also to propose recommendations to reinforce existing solutions and to avoid common errors. Thereby, it would be necessary to collect data concerning the efforts that were taken by the population in the past, and to contribute to the restoration and repair of the buildings that sustained damage from the earthquake.

Regarding the assessment general aims, the project relates: 1. To identify local seismic culture and architectural seismic resistant features throughout the Portuguese regions exposed to frequent tremors, even with low intensity, and earthquakes with high intensity but less frequent. 2. To identify materials and techniques to repair and restore damaged in-use vernacular buildings, related with local population reactive efforts to earthquake occurrence. 3. To identify actions addressed by the local community, on their attempt to prevent from earthquake damage.

The plan description is structured under 5 phases: Phase 1 will identify the Portuguese regions with seismic resistant vernacular architecture, as well as if there is a local seismic culture present, through quantitative and qualitative data collection and analyses, literature review, drawing surveying, and data mapping, creating an Atlas (Task 1). In phase 2, the question to address will be, if vernacular architecture seismic resistant features are still in good use? To respond to the question, experimental characterization needs to be addressed through the analyses of selected and representative case studies. Results will emerge from comparative analyses of material, structural solutions, building configurations, dimensions, as well as non-destructive tests (Task 2). In phase 3, the question relates to the vernacular architecture performance, in case of an earthquake? Numerical modelling with parametric studies originated from quantitative analysis will be created to compare the buildings performance under earthquakes (Task 3). Following, phase 4 will respond to the question: How to reduce the vulnerability of in-use vernacular architecture, in case of earthquake occurrence? The identification of common mistakes and the proposal of reinforced solutions will address the research problem. An analysis of results emerging from task 2 and 3 will be correlated with findings from task 1 (Task 4). Phase 5 will present findings emerging from buildings performance under earthquakes, as well as solutions regarding seismic resistant features. Recommendations are proposed for local communities vernacular housing (Task 5).

The project will be structured by tasks to respond to the plan. The plan is therefore addressed through 5 progressive tasks. Task 1: Definition of the areas of study, according to the intensity and frequency of earthquakes, supported by the survey missions and preliminary analysis. The task will result in an Atlas of Local Seismic Culture in Portugal. Task 2: Experimental characterization (in situ), to study the materials and their application through benchmarking in paradigmatic cases. Task 3: Numerical modelling and parametric studies, which will be developed through testing, whose conclusions will be presented in Laboratory Seminars. Task 4: Identification and description of the most efficient seismic resistant reinforcement solutions, as well as the most frequent errors. A manual of practical construction "warning of erroneous solutions," will be produced directed to communities and local agents. Task 5: Finally, the Project will systematize the information collected and produced, featuring the analysed solutions. According to their feasibility study, it will be prepared a publication, meticulously verified by the scientific advisers, to become an important contribution to knowledge.

Regarding the coordination of tasks, ESG will be in charge of Task 1, 4 and 5 and will contribute to the other tasks. Completing ESG know-how in the vernacular heritage disciplinary area are the Engineering Departments of the University of Aveiro (UA) and the University of Minho (UM) with strong experience and output in seismic research. UA will be responsible for Task 2 and will contribute for Tasks 3, 4 and 5. UM will coordinate Task 3 and will contribute for Tasks 1, 2, 4 and 5.

The outcomes of the research project will be: a) Recommendations for reinforcement of in- use vernacular housing seismic features. The project findings might save lives in case of earthquake occurrence. b) An atlas on vernacular architecture and LSC; c) A scientific publication for best dissemination of results among the scientific community. d) A graphic publication, as a booklet, for best dissemination of results among the local community and municipalities. e) Training for local agents regarding LSC, through technical seminars, which will become an important milestone for training of Municipal technical counsellors located in seismic regions. For a better dissemination of results, data collection and outcomes will be presented

through three major milestones:

- an International Conference on Vernacular Heritage and Earthen Architecture CIAV2013|7ºATP|VerSus, co-organized by ESG, from the 16-20 October 2013 (www.esg.pt/ciav2013) to reach the national and international scientific communities. One of the conference sub-themes, Natural Hazards and Risk Mitigation, was define to collect data and to partially respond to SEISMIC-V research problem.
- One scientific publication, with the most important project contributions, to be distributed worldwide;
- 5 Technical Seminars, organized by the survey laboratory groups to respond to technical training and feasibility studies.

The project gathered National and International support for the dissemination of results. Due to the importance of the research problem, the Portuguese Ministry of Culture supported the research project, contributing for LSC awareness, at regional and national level, through the institutional impact that can grant the dissemination of results. SEISMIC-V also received the support of ICOMOS-CIAV, ICOMOS-ISCEAH and the European University Centre for Cultural Heritage (Ravello, Italy).

The research problem will be methodologically addressed and comprehensibly implemented. Furthermore, the overall findings of SEISMIC-V project will provide data to reinforce architectural seismic resistant features, which in case of earthquake occurrence can save lives.

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Title: Earthquake resistant design of traditional building cultures in Nias, Indonesia

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Country: Austria

Abstract:

The traditional architectural typologies of the remote island of Nias have evolved to adapt both to environmental conditions and specific requirements of society and culture. Specifically, earthquake resistance was generated by way of structuring of buildings and settlements. A study on the village of Hilimondregeraya in a comparative approach shows the changes during the last decades and the situation after the big earthquake in 2005. Using available photographic documentation of researchers that visited the village during the timeframe of almost a century, starting with evidence produced by the Danish explorer Agner Møller in 1923-27. Later records were taken by Feldman, Viaro, Kurt-Nielsen, Wolff, Gruber, Herbig, Mechler and Zamolyi. The comparison of photographs and reports over this timeframe delivers information about the development of cultural heritage and the boundary conditions for its preservation for the future.

Earthquake resistant design of traditional building cultures in Nias, Indonesia

Introduction

I first visited the Nias island in the course of a field trip of a group of IVA members to North Sumatra in 2003 (HERBIG & al, 2005). After the tsunami and the big earthquake in 2005, Ulrike Herbig and I started an interdisciplinary research project to help documenting the island's unique architecture. The field trip in summer 2005 showed that, although heavy damage has occurred, the traditional architecture has proven to be outstanding resilient to the disasters. Our approach to the Nias architecture is diverse: we are interested in the adaptation, earthquake resistance, and the documentation of the culture and of cultural changes.

Figure 1: North Nias house in Sihare´ö Siwahili

Traditional house - typology

The unique traditional architecture which still exists on Nias can be categorized into distinct typologies according to the cultural regions (FELDMAN, 1977). North Nias houses have an oval floor plan with slanting walls all around, rows of vertical pillars and diagonal bracings (X-shaped) in the substructure, and a huge hat-like roof. Two central pillars lead from the first floor to the ridgepole. The hybrid typology of Central Nias houses has not yet been fully examined. Research on its origin and influences on North and South Nias types will be an important part of a future research project. Middle Nias houses have rectangular or cross- shaped floor plans, slanting sidewalls, a slanting front facade, and V-shaped diagonal bracings in the substructure. Very different layouts of the floor plan are possible. South Nias houses have a row house-like rectangular floor plan, straight load-bearing side walls, a slanting front facade, a V-shaped diagonal bracing on the front facade, and a very high roof. The "Omo Hada", the traditional house, is built according to traditional law.

This "Adat" regulates all activities of life and, thus, all steps and rituals related to the building process.

The traditional houses on Nias provide living space for one family. They are entirely made of wood and other plant materials. Apart from the few remaining Omo Sebua (the big houses of the kings), today's houses are entered from the side by means of ladders or staircases which are sometimes covered by annex buildings. The kitchen, the toilet, and the mandi, the traditional bath, are placed in annexes in the back. All traditional houses on Nias have large lattice openings in the front facades and window flaps in the roof: this kind of opening is specific for the island of Nias and cannot be found anywhere else in the Indonesian Archipelago. The common characteristics and differences in construction will be described in the following.

Figure 2: Interior views of North Nias house in Sihare´ö Siwahili

Figure 3: Omo Sebua in Hilinawalö Mazingö

Structure of the Omo Hada, the traditional house

The most obvious feature of the Omo Hada is its three-partite structure, the vertical zoning into three distinct levels. The houses rest on a grid of vertical and oblique posts placed on slabs of stones. The three-dimensional structure offers great resistance and elasticity since it does not settle in the ground. The separation of the house from the ground is an important concept for traditional earthquake- resistant construction.

The first floor - the living floor - is separated into public, private, and transitional spaces either by wooden walls or changes in the height of the floor. This organisational element of space is most elaborate in South Nias houses and is also used on the village level. The living floor is a very stable boxlike structure. Even if the substructure should collapse, the box persists[1].

Large openings along the entire front facades provide good ventilation and a superb view of the neighbourhood, thus, ensuring a good control of the contact between inhabitants and outsiders. The houses are only scarcely furnished; the inhabitants' belongings are stored in chests. The most important piece of furniture is a long plank below the louvers, which the tenants use as a bench.

The steeply pitched roofs are another notable feature of Nias houses. Still most of them are covered with palm leaves although the use of corrugated metal is becoming more popular The high multi-storey construction rests on two main pillars in the North and Middle Nias types and on sidewalls in South Nias. The Omo Sebua can reach a height of more than 20 meters. The construction is a light 3D structure, usually minimizing the material used. Large overhangs protect the wooden connections against rain and provide additional outside space.

Adaptation

This "natural architecture" seems to be very well adapted to the environmental conditions on the island in many respects (VIARO, 1990). Adaptation refers to topography, tectonic situation, climate, resources, and material as well as to society and culture and can be interpreted as an ongoing process. The architecture on Nias has evolved over a long period of time and in a constant process of empirical effort for improvement. The knowledge implemented in the developed ty-

1 According to interviews with the village chiefs, in the eleven South Nias villages we have visited nobody had been killed during the 2005 earthquake due to the breakdown of a traditional house.

pologies is the source of innovation which we want to use in a process of "quality mining" to develop further solutions. The outstanding resilience of the houses to earthquakes might be the reason for the survival of these building types, which are endangered for many reasons, and is the most interesting characteristic that should be investigated.

Research of the development from one typology to the other depends on further studies of the Middle Nias architecture, which exists in so many variations that a Middle Nias typology cannot be clearly defined. The "Niha" claim that their origin is in this region (FELDMAN, 1977 ; HÄMMERLE, 1999), but a common ancestral building type is questionable.

Topography - orientation

The traditional settlements are never by the sea, but further inland. The main street axis is usually oriented along the direction of the mountain ridge. Together with a good drainage system along the main street, this orientation allows the fast outflow of huge amounts of rainwater. In the mountainous Middle Nias, villages are located in the river valleys. In the North and South, hilltops are the preferred location, which also provide a good protection in a tribal society in which warfare was endemic.

Climate - humidity and ventilation

The climate on Nias is tropic, warm with a humidity of 80-90% and an average of 250 days of rain per year with frequent storms. Thus, the ventilation of the internal space is very important: the large window openings, the latticework sidewalls of the South Nias houses, and the huge roof space with the semi-permeable covering of palm leaves is a perfect passive ventilation system. In former times, when the fireplace used to be inside the houses, the roof space was even more needed for the evacuation of smoke, which had a protective effect on the natural covering. The stilted structure allows an open airflow beyond the living space, which may also add a cooling effect, but certainly is an effective way of protecting the constructive wood. The steep geometry of the roofs is important for the fast outflow of rainwater. The break in the pitched surface is a typical solution found in many tropical buildings to construct a large roof extension, which is needed to protect the wood. The form is a compromise between structural necessities (maximum length of beams, load transfer, and stability) and maximum depth of the house.

The covering made of palm leaves is more and more being replaced by metal. The rusty colour may be a matter of personal taste, but from the building physics perspective the material is bad in terms of humidity, permeability, heating effects, and sound. The positive characteristics of metal roofs are their price and durability. Considering the fact that the roof is the most important means for wood protection, metal roofs may be acceptable in spite of their disadvantages. Finding another (cheap) material which is as good as the palm leaves covering would revolutionize building in the tropics. The challenge for future designers is to achieve a good room climate without active air conditioning systems.

Details and materials

Only locally grown plant material was used for the traditional houses. No metal pieces were needed. Elaborate mortise and tenon connections are used for the constructive parts. According to the location within the construction, different kinds of wood are used, the hardwood Manawa Danö in the North Nias houses and huge plates of ebony in the South Nias kings houses being the most impressive ones. Apart from the wood, palm leaves, bamboo, and binding are still used for the roofs. Slabs of stones provide the foundations and sometimes the pavement.

Correlations between house typology and settlement

There is a necessary correlation between the settlement structure and the building typology as well as the society in the respective area. The spatial order reflects social and cultural conditions and needs. In former times, there used to be a kind of king's or chief's house (Omo Sebua) in all regions. Only in South Nias a few of them have survived.

- North Nias - disperse settlements

Traditional villages in the Northern part of Nias either consist of groups of six to twelve oval houses, which are oriented longitudinal-side towards the street, or of single cottages far away from each other. In the past, the settlements were fortified with fences of bamboo or with earth walls overgrown with trees. Traditionally, megaliths are placed in front of the houses. These stones symbolize the connection between the living and the dead. They reflect the social status of the house owner. Nias is famous for its megalith culture, culminating in the elaborate pieces in South Nias. The houses were entered from the village square, through a bottom flap underneath the house. A staircase has replaced this entrance or a front porch as this defensive preparation is no longer needed.

- Middle Nias - disperse settlements with single or combined houses

Settlements in Central Nias consist of scattered single buildings or combined houses. Although the settlement history of Nias is said to have its roots in Central Nias, nowadays the architecture of this region appears to be a hybrid of northern and southern styles. Just like in the villages of North Nias, the settlements are a collective of single buildings. However, different from the North, the houses can be combined and are situated with their eaves facing the village square. This orientation and the rectangular floor plan are also found in the South Nias villages, but there is no exact definition of public space. The space in front of the houses is paved with stones and is used for drying agricultural products or laundry. Stairs and steps are used to define spatial relations. Interestingly, the combination of two Middle Nias houses exists in two variations: sharing a common entrance space in between or standing closely together with two separate entrances on the sides. Both variations together create a row house structure like that of South Nias villages. Characteristic features of the architecture in Central Nias are decoration and ornamental art. At the fronts carvings, patterns and animal representations are to protect the house and its inhabitants. Symbols inform about the conditions of the family regarding fertility, for example the number of women living in the house.

- South Nias - dense settlements with row houses

Villages in South Nias are situated on hills and are named after their location. In the past, when warfare and headhunting raids were endemic, an outer palisade of sharpened bamboo stakes with a deep ditch behind it fortified the village. The settlements can consist of several hundred dwellings arranged on either side of a paved street, which may be up to 100 meters long. The basic linear street pattern can be enlarged to T- or L- shaped configuration. The form of these villages reflects the structure of the Nias society. One village initially is the settlement of one clan. People live together in

Figure 4: House in the Gomo area

Figure 5: Street view in Hiliamaeta

a very narrow space, under constant control. Between two coupled houses, pairs of adjacent households share covered entrance terraces. Neighbouring houses are also connected with doors to provide escape routes. The houses have a public room in the front and sleeping rooms in the back. The front room is lighted by an opening, which stretches over the entire street facade and is secured by a wooden grid. Just like in the North, furniture is sparse. Constructive elements of the cantilevered front facade create different floor levels in the interior space, being used as benches and for storage purposes. The standard type of the South Nias house is a rectangular-shaped elevated row house construction, oriented with the eaves towards the street. The substructure is made of four rows of strong pillars (Ehomo), reaching from the ground to the first level. Diagonal posts (Driwa), like those of North Nias houses, support them. But in contrast to this typology, the V-shaped columns are situated at the very front, acting as supportive and representative elements. Again, all house posts rest on foundation stones, on the one hand to prevent them from rotting and on the other to make the construction as a whole more flexible. The space created beneath the house is used as a storage space and as an animal shed. Alternative house forms developed at places where traditional houses had been torn down.

Society and space in South Nias

Society and space are strongly connected to each other in South Nias. The settlements have distinct entrances and centres, with the distance from the centre correlating to social importance. Space is ordered hierarchically mostly by means of a differentiation in height. Due to the elevated sites, grand stone staircases form the beginnings of the village streets, flanked by symbols of protective animals, i.e. lizards. Entrance situations are always accentuated. The house of the chief, the Omo Sebua, usually had the largest structure

Figure 6: Omo Sebua in Bawomataluo

and is located at the center of the village. In some villages, more than one Omo Sebua existed.

- Centre

The Omo Sebua in Bawomataluo (with a zinc roof) is located at the centre of a T-shaped village with a zone of megaliths in front. Apart from this one, these big houses are placed on higher platforms with staircases, which enhance their impressive emanation. In Hilinawalö Mazingö, the Omo Sebua is located most impressively at the end of the inclining main street axis. On Nias, only four Omo Sebua still exist. The loss of these structures due to a change in society is usually followed by a fast decline of the traditional architecture in the village. To keep the structures alive, a new function would have to be found. A traditional building type of meeting houses was a special kind of the common meeting house, the "bale", which was situated close to the Omo Sebua in the center. This typology is almost lost; only one building of this type still exists in Bawomataluo. Modern meeting houses are common and situated in the centers of the villages.

- Hierarchy of space: transition from private to public spaces

The most private space in a traditional village is the rear of the house, while guests are welcomed in the living room in the front. Between two coupled houses covered entrance terraces are shared by pairs of adjacent households. Neighboring houses are also connected with doors to provide escape routes, which were needed in the past.

The front space below the roof overhang

Figure 7: View out of the Omo Sebua in Hilinawalö Mazingö. The only real public space is the walkway.

along the street is a semi-public space and used for working, socializing, and transition. A drainage gutter defines the border. The following area towards the street is reserved for the megaliths as a representation space. This zone is called “wall of stones” (*öli batu*) and indicates the rank of the householders. The megaliths are a kind of petrified model of the social hierarchy and feasts of merit. The stones are classified by gender, and come in a variety of forms, which include menhirs, benches, and circular seats.

The space between the *öli batu* and the public walkway in the middle of the street belongs to the respective house and has to be maintained by the owner. It can be used for drying agricultural products or laundry. In case of a catastrophe causing heavy damage to the houses, the space is used as a temporary shelter.

Qualities

The advantageous qualities of the traditional architecture are what we want to define and investigate. The documentation and understanding of these qualities shall help in the process of the design and implementation developing into modern architecture.

- Form

The diagonal bracings of the substructure, the tripartite structure of the houses in general and the impressive roof are very strong architectural forms, which are easily recognizable and allow identification. All three have been transformed into signs, abstract drawings, and models.

Figure 8: Interior view of South Nias house in Bawomataluo

- Spatial quality

The spatial quality of the interior spaces is very good. Orientation is provided by the big window openings. The heat is avoided, but there is just enough daylight to make living comfortable. The spatial order is provided by differentiation in floor height and separation walls. The elaborate design (and sometimes ornamentation) of the front room and the side walls make a very calm and stable impression. According to tradition, the dark volume of the roof is not separated by a ceiling: it provides an endless dark heaven to the living floor.

The use of space is strongly and hierarchically defined and characterized by a specific grade of privacy or publicity. This hierarchy of space defines the activities which may take place there and enables the inhabitants to live very closely together, in the house as well as in the village.

- Excellent craftsmanship

Craftsmanship definitely has been excellent on Nias. However, only a few tukang rumah (i.e. masters of house-building) are left and traditions and techniques are on the verge of being lost. The tradition of wood working shows parallels to a megalithic culture. Similar ornamentation can be found in stone and in wood. The detailing proves craftsmanship in woodworking in best execution, as found in other countries like Japan, Russia as well as in Austria.

- Climatic condition

Due to the good ventilation, the large air volume in the roof, and the ability of wood to adapt to a certain aerial humidity, the climatic condition inside the house is excellent, without active air conditioning. The construction of the house as a whole also provides enough covered outside space so that any kind of activity is possible, even in times of strong rain.

- Earthquake resistance

The construction seems to withstand even very strong earthquakes. We have already formulated some hypotheses as to how this quality is achieved and we will try to prove them in a future research project. The security of the inhabitants has been de facto proved as nobody was killed due to the collapse of a traditional house during the big earthquake in March 2005.

- Sustainability

Initially, all material used for building was found on the island. As archaeological investigations show, the island has been inhabited for at least 1500 years (HÄMMERLE, 1999). Due to unavailable data on environmental conditions in the past, sustainable material use cannot be proven. If we project the estimated global building related material use of 50% (EDWARDS, 2001) on Nias, building must have contributed to the disappearance of many kinds of trees on the island and to the disappearance of the primeval forest in general. Nowadays, there is a lack of wood for building. Thus, in particular the North Nias houses with their substructure of Manawa Danö hard wood cannot be built any longer.

The research project

Our research project started with the field work in 2005 and still continues with the processing and analysing of the data we have collected by taking the following steps: documentation, testing of wood characteristics, structural analysis using virtual models, confirming hypotheses with micro-tremor analysis, and conducting experimental design. A rough survey of the damage has been done in many regions of Nias. Especially in the South, eleven villages have been surveyed and a set of statistics has been compiled. Six different houses, three in each region on Nias, have been measured in detail. 2D plans have been drawn of all house types. 3D models are used for visualization purposes and to create virtual models for a structural analysis.

The hypotheses regarding the effectiveness of the houses have been created together with collaborating engineers on the basis of field work investigation. The structural analysis will be used to verify the concept.

The characteristics of the kinds of wood which are used for the Omo Hada have not yet been tested according to the European Building Code. To do so, we have collected samples of the most commonly used kinds of wood and are currently running tests at the Vienna Technical University in collaboration with the Institute for Building Construction and Technology.

To make the models even more concise we plan to carry out a micro-tremor analysis of the documented buildings. This new method delivers information on the flexibility of the building as expressed by the natural period.

Seismic loads and deformation

The earthquake force, the “shaking” of the ground, is difficult to grasp. The shock in the epicentre initiates a complex wave-like reaction. For engineering purposes, the shaking has to be translated into distinct horizontal and vertical forces. What is of extreme importance is the frequency of the waves due to resonance effects of the ground and/or the building. The “natural period” value of the building (time of a single tremor) determines the probability of heavy damages on the basis of the frequency analogy with the earthquake waves and subsequent amplification effects.

The damping factor (trend with which the vibration decreases after the loading) depends on the structure and the material properties. For static analysis, the earthquake frequency is taken from historical examples. For a house to be earthquake resistant, its natural frequency should differ as much as possible from that of an average earthquake to avoid the amplification effects. The natural frequency of the ground likewise has to be taken into account.

Concerning the immense earthquake on March 28th, 2006, geologists stated a magnitude of 8.7 with a severe to violent peak ground acceleration and a severe to violent ground velocity in the Nias region; the centre of the island was hit even harder (USGS, 2005). Geological contour maps give information on the movements in the area of Nias, showing an immense vertical uplift that has occurred along two ridges on Nias and Simeulue (BRIGGS & al, 2006). Parts of the west coast of Nias have been lifted two meters. Enormous deformation and ground liquefaction have taken place, destroying bridges and streets, infrastructure and buildings.

Impact of the earthquake in March 2005

The earthquake has caused the worst damages in the populated coastal areas, especially in the capital Gunung Sitoli, intensified by bad alluvial soils and cheap concrete structures. On the entire island of Nias, 758 people died, 705 were badly hurt, 781 hurt and 84,388 persons internally displaced, i.e. in camps or with host families (IOM, 2005). About 50% of all public buildings have been destroyed as well as many streets and bridges. Out of 122,652 housing units 71,000 have been damaged or destroyed[2].

The commonly poor economic situation of the island has been boosted by the recovery efforts of the government and international help. However, this upswing coincided with high inflation and a serious shortage of raw material, which have both hampered the reconstruction until today.

Situation in August 2005

Our own survey on traditional villages in South Nias shows the damage to traditional Nias architecture. In most villages, less than 50% of all houses are still Omo Hada; the others have been replaced by wooden Malayan style houses or simple concrete bungalows. Large modern village extensions change the picture. In the villages we have visited, between five and 30% of the total number of houses were damaged traditional ones[3]. About one third to a half of the remaining traditional houses have been damaged by the quake, mostly older buildings and badly adapted ones. Thus, the main reason for the damages of traditional houses is bad maintenance.

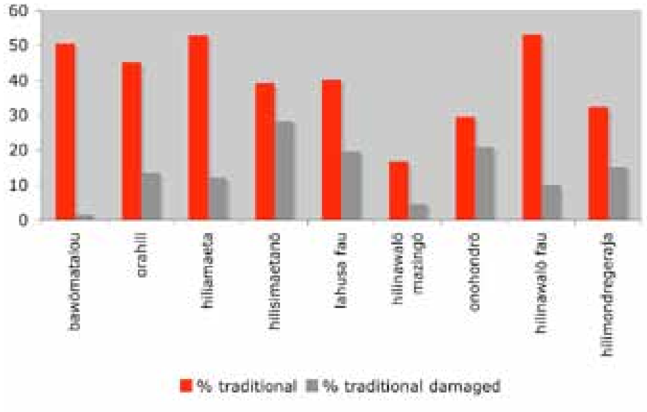

Figure 9: Statistics of damage in South Nias villages

There seems to be a correlation between the economic situation, which depends on the situation of the village, and the maintenance of the traditional architecture. The more remote the villages are, the poorer they usually are. The lack of building material aggravates the situation and people do not have the resources to repair and maintain the houses any longer.

Variation in the level of damages

We could observe major differences in the level of damages, concerning both, modern and traditional architecture. This corresponds to observations made by scientists of the Centre for Disaster Mitigation in Bandung. The following factors are responsible for the variation: amplification of peak ground acceleration due to local ground conditions, liquefaction of the ground, differences in the vulnerability of the buildings and their foundations.

As the variety of ground condition is so vast, scientists suggest developing a microzonation hazard map for North Sumatra and Nias (CDMB, 2006), which is not yet available though.

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2 BRR numbers revised by UN-Habitat to : 39.022 not damaged, 75.635 less than 50% damaged, 7.995 more than 50% damaged, published 23.01.2006, in: Housing Damage and Reconstruction Needs in Nias and Nias Selatan.

3 Figures according to field trip Gruber/Herbig (2005).

Topography and ground condition

A stability of the site is required for any earthquake resistant building. As traditional villages are located on hilltops, the ground conditions in general are very good and the building sites seem to have been well chosen. Usually, the more dangerous soft soils along the rivers have been avoided. The example of the village of Siwalawa illustrates the regional differences: the old settlement cores are on stable ground, whereas a landslide destroyed newer developments in 2004. We have found disruptions along the main axis of the villages, a characteristic and often observed damage, which might be a result of a general uplift and deformation of the island as a whole.

Common characteristics of traditional architecture in terms of earthquake resistance

The following characteristics of the traditional houses relate to their earthquake resistance:

- good sites,
- material: wood,
- „soft“ mortise and tenon connections,
- no embedding in the ground,
- three-partite structure, structural separation,
- diagonal bracing.

The different building types, which have evolved in Nias, have a different structural performance, while there are undoubtedly common features as well.

Influence of the material

In the earthquake in March 2005, most casualties occurred due to collapsing concrete structures due to a “pancake”-like collapse caused by heavy shaking of

Figure 10: Facade detail in Bawomataluo

the ground and the poor quality of material and detailing. In contrast, the advantageous characteristics of wood, not only in the traditional, but also in the Malayan style buildings saved many lives. Wood has excellent dampening characteristics and is comparably light. Thus, no complete collapse occurs, no heavy pieces fall down on the inhabitants, and the material can be reused. Apart from the characteristics of materials, skilled workmanship is likewise important: many concrete buildings collapsed because of poor materials and poor workmanship, in addition to the common building step by step due to a lack of funding. In contrast, the knowledge on building with wood is still very good.

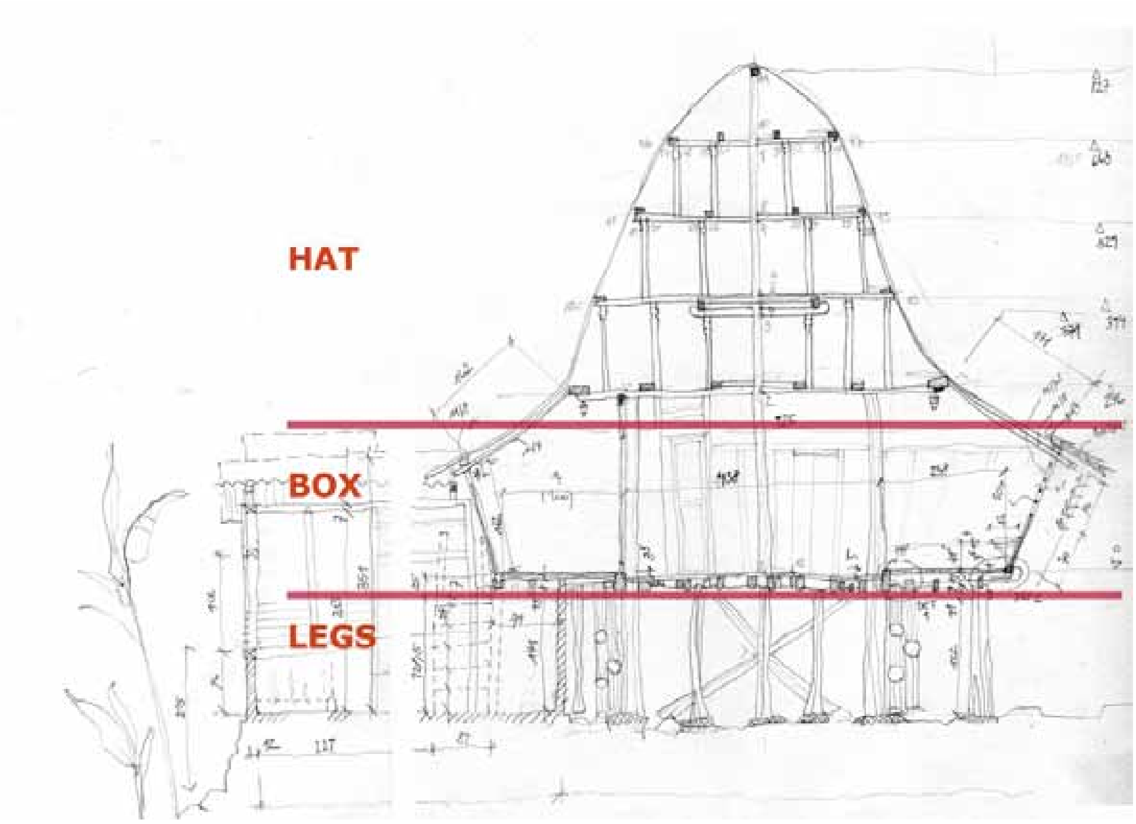

Figure 11: Cross-section of a North Nias house, hat - box - legs

Detailing

Elaborate mortise and tenon connections are used to connect different elements which are secured with wedges and are, therefore, very "soft" connections, allowing considerable movement before breaking.

If all elements remain intact and the structure can be brought back into the initial position, the detail can be easily fixed again. Dismantling the houses and rebuilding would be possible as well.

Foundation

The traditional houses are stilted constructions, placed on slabs of stones. As far as we could find out, the ground is not treated in any way before building. The slabs of stones, which are used as a foundation, seem to be placed randomly, and the pillars not really adapted either. In most cases, the ground below the house is not paved. Exceptions exist in Middle and South Nias. We do not know whether in former times the ground below the houses has been paved or not. What is more important is the space around the house. In South Nias elaborate drainage exists for the outflow of huge amounts of rainwater, which prevents washing away of soil and thus renders it unstable. The central foundation stones of the kings' houses have elaborate carvings.

In case of any external force, the movement of the entire building is possible without breaking the stilted substructure. Movement and a minimal sliding of the stilts on the respective foundation stones frequently occur. The transmission of horizontal forces from the ground to the structure is not possible technically.

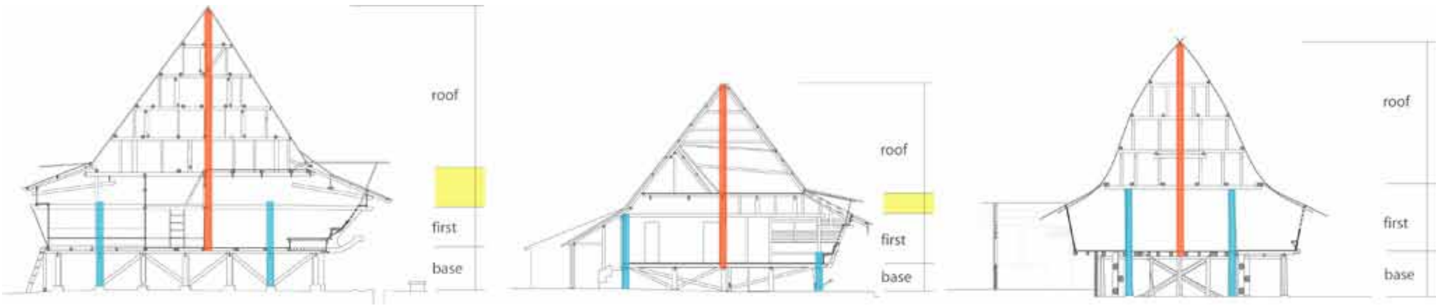

Figure 12: Comparison of cross-sections

Three-partite structure

The three-partite structure is not an exclusive feature of the Nias houses. This form of building is ubiquitous in the Indonesian archipelago and other regions with tropical climate and has many reasons and advantages. In terms of earthquake resistance, a three-partite structure is advantageous. The “legs” of the substructure provide resistance against the impact of forces in vertical and horizontal directions. Originally, this space is not used as a living space, but as a storage space and a stable. The living floor acts like a stable “box” stiffened by the inside walls, which is open to the roof space. The “box” persists even if the substructure collapses. The roof is a light, open structure, a “hat”, which does not endanger the inhabitants. There also is a considerable structural separation on the different floors.

Altogether, the house acts like a legged box with a light hat, hence, combining the two crucial concepts of earthquake resistant design: flexibility to absorb the energy of seismic shocks and stiffness to protect the inhabitants.

Structural comparison between typologies

A comparison of the cross-sections of the different typologies shows the elements that connect the three zones. The most remarkable structural feature is that no element connects all three zones. Four pillars connect the substructure with the living floor and two pillars connect the living floor and the roof. The number of connecting elements seems to be reduced to the absolute minimum.

In Middle and South Nias type houses, a structural in-between zone exists between the living floor and the roof. An element which is close to a wooden truss spans over the entire depth of the building. This again shows the close relation between the Middle and South Nias type of house.

Especially in South Nias houses, the roof contains heavy horizontal beams, which are not needed to hold the covering or define the geometry. According to our hypothesis, these beams are placed there because of their weight, to keep the centre of gravity at a certain point. The overall weight and the vertical distribution of weight again refer to the natural period of the roof as part of the building.

The previously mentioned structural separation of the floors corresponds to the damage symptoms. We have observed a considerable movement between the zones, especially between the living floor and the substructure. Thus, cases of a complete collapse have to be attributed to the failure of the substructure. The movement between the zones stresses the interconnecting elements. A failure of the connection and the breaking of the elements show areas of force transmission.

Figure 13: Diagonal bracing in North Nias, Sihare´ö Siwahili

Figure 14: Damages in Hilimondregeraja

Diagonal bracing

The diagonal bracing in the substructure is the most obvious special feature of Nias architecture and seems to be responsible for its earthquake resistant behaviour. According to the respective building typology, the diagonals are placed in rows inside or outside a grid of vertical columns in both directions. In South Nias, they are situated as a huge V in the front facade. With their detailing, the bracings can absorb the pressure part of the external force, but can take tension only to a limited amount as they are not well anchored in the ground.

In all building types, the bracings can transmit pressure in the basement detail, and both pressure and tension on the upper end detail. Sometimes the triangular space is consciously filled with heavy stones. The weight of the storage ameliorates the functioning of the diagonal bracing: the pressure of the weight acts against the lateral movement of seismic shocks.

In South Nias, the X-shaped bracings have been transformed into V-shaped ones. This intelligent variation replaces the bad base detail of North Nias houses with a self-stiffening system of two pieces forming the bearing of one another. The structural integration of the bracings into the primary construction system in the floor between substructure and living box is bad in all of the building types. This indicates that the bracings are a later development, possibly found useful as an adaptation to unstable ground conditions and the frequent earthquakes. A movement of the bracings have occurred very often and they seem to take the main loads of the seismic shocks. From a structural perspective, the bracing connections are "hard" compared to the overall construction. Furthermore, the connecting parts are not designed to take the transmitted forces, as the typical damages show. The overall result of a failure is a tilting of the upper floors.

Perseverance of the "box"

We have only seen a few houses that have completely collapsed[4]. But even then, the space in the living floor has remained unobstructed and free. So the "box" in all cases observed has remained stable and provided a good shelter. Nobody in the villages that we have visited has been killed during this earthquake in a collapsing house.

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4 Taking into account that our field trip took place three months after the quake, some of the collapsed houses might have been torn down already. For this reason the empty sites have been added to the set of statistics.

Figure 15: Omo Sebua in Onohondrö

Figure 17: House in Bawölato

Reasons for damage

- Bad state of preservation, material integrity

The better economic situation of those South Nias villages, which are accessible by car, showed that a good preservation of the houses is necessary to maintain good qualities. As a matter of fact, richer settlements have not at all or much lesser been affected by damage. Maintenance is especially difficult for the big kings' houses, since the descendants cannot afford it.

Because of the remoteness of the villages in the South, help had not reached many places by the time of our field trip. People obviously had not had the resources for maintaining the houses for quite a while. Bad maintenance is the main cause of damage of traditional houses. Apart from an inadequate roofing, the humid climate is a factor influencing bad durability.

- Damage of the roof covering

Damaged roofs have been ubiquitous, especially concerning the cover (palm leaves on split bamboo), less often concerning the structural parts. The integrity of the roof is crucial for the preservation of the houses.

- Lack of knowledge

Apart from the renewal of the roof covering, there seems to be no tradition of regular repair or renovation measures. Ill-planned adaptations of the houses and bad protection and reconstruction work show a profound misunderstanding of the structural functioning.

- Endangered structural integrity

Structural integrity often turned out to be endangered due to changes to traditional construction. The removal of structural parts, especially of the substructure, is often carried out to gain unobstructed space in the basement. However, roof extensions and second living floors move the center of gravity upwards. The collapse of annex buildings has led to the damage of the traditional parts, i.e. the upper tension ring in the North Nias type.

Adaptation of traditional structures

An important functional change was introduced in colonial times: the removal of fireplaces from the inside of the houses to the outside. Subsequently, a tradition of annexing kitchens and bathrooms has developed, but no building type has yet evolved (even though water pipes are provided, drainage is still a problem).

Figure 16: Metal roof coverings in Hilinawalö Fau

Figure 18: Procession on the national holiday 2005 in Gunung Sitoli

The entrances to the North Nias houses, which are obviously a recent invention, focus on individuality.

The strongest adaptation concerning the material is the use of corrugated metal for the roof covering. Even if the appearance and room conditions suffer, these roofs have saved many houses, including the Omo Sebua in Bawomataluo. In addition, electricity cables and satellite receivers have changed the appearance of the villages.

Adaptations exist in various forms as the Niha are very inventive. Middle Nias in particular offers a great variety of floor plans and constructions. However, the need for floor space has sometimes resulted in dangerous changes to the traditional building structure.

Identity

What has been learnt from tradition is formal reinterpretation. The strong forms delivered by tradition are translated into modern building, but they lack their former constructive function. We have observed a few extreme examples of imitation of entire traditional South Nias houses in concrete and brick. More often, the diagonal bracings have been used. They have become a symbol of a stability, which could have been provided much more easily using concrete as a building material. The diagonal bracings and the steep roofs of the Nias houses have become a characteristic emblem for Nias, which is also used for public buildings. Especially entrance gates, annex buildings, and porches are being transformed into symbolic Nias houses.

In North Nias, close to Gunung Sitoli, we have found a few Rumah Adat, which have been renovated in a new or modern way and which were obviously owned by rich families, who possess a Omo Hada as a status symbol.

Bad models of Nias houses are ubiquitous and are being sold as souvenirs. Very creative models of Nias houses were being carried around in a procession in Gunung Sitoli on the national holiday in 2005. All this shows that the inhabitants of Nias are well aware of their architecture and will hopefully be able to maintain this unique tradition.

Conclusion

Documentation as a source of information for understanding the traditional architecture is essential in many respects. Preservation of the remaining houses should be undertaken. Our research will create a better understanding of the structural performance of traditional houses. With experiments on virtual models we will further investigate ways to ameliorate earthquake resistance with affordable means.

To counter the frequent earthquakes on Nias, the following future measurements are being proposed:

- A microzonation map for Nias is urgently needed.
- The awareness of owners of preservation measurements should be heightened and a funding system for owners of traditional houses should be established.
- A new kind of roof material should be researched and provided.

Adaptation should be continued, preferably according to two different ways of transformation: adaptation of traditional buildings to fit modern conditions (security, infrastructure, comfort, material) as well as of the global building style to regional knowledge, implementing the qualities of the traditional houses and settlements. Both ways will lead to a "new tradition" which combines old and new qualities. Our research project serves as a documentation of the present situation, and we hope to initiate the support of reconstruction efforts. Traditional knowledge and qualities should not be lost but be interpreted in a new and modern way.

Design program surfresort Nias

In the winter term 2005, we carried out the design program "Surf Resort Nias" at the Department for Building Construction. The program suggested a small hotel development located in Sorake Beach, where a declining economy, the tsunami, and the earthquake have devastated a community of small- scale tourism. Some of our preliminary findings had been introduced into the student projects, which are represented by three very successful examples. Triangular bracing, stilted construction, large roof volume, natural ventilation, differentiation in height, conscious material selection, careful consideration of building process – these principles used in the traditional architecture were interpreted in the design proposals, which are the first step towards a better adapted, high-quality architecture.

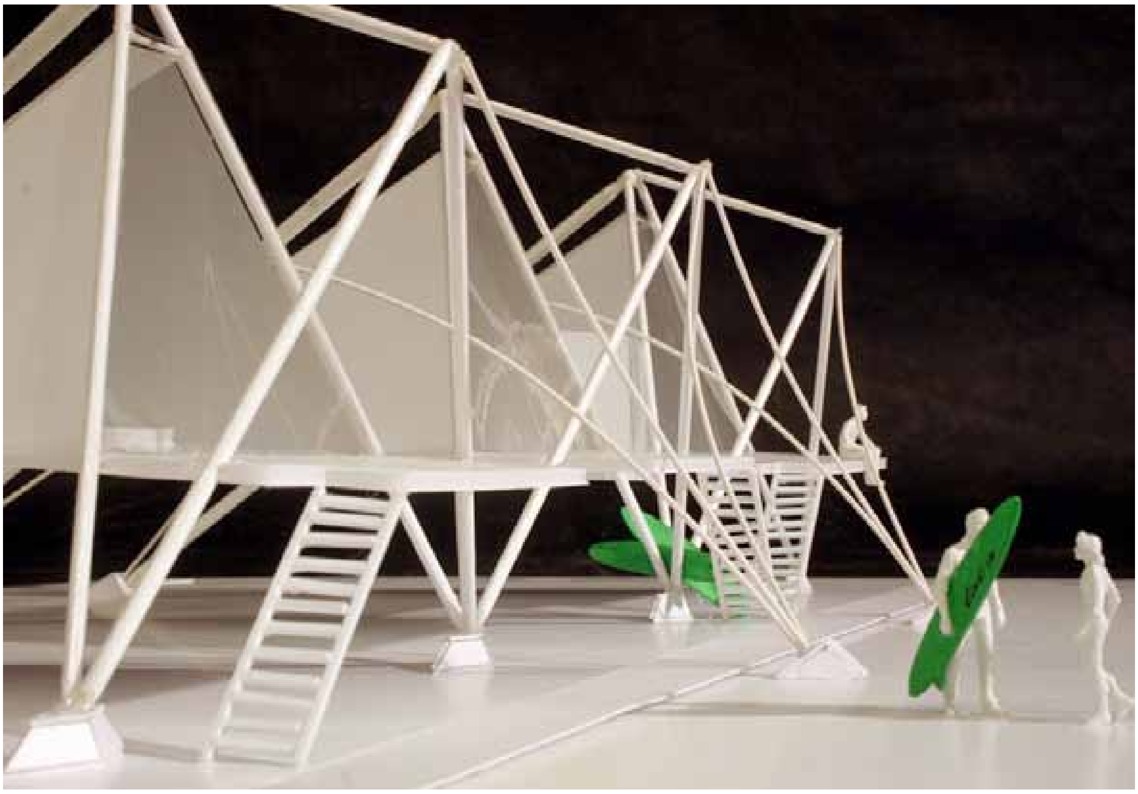

Figure 19: Project by Catrin Huber

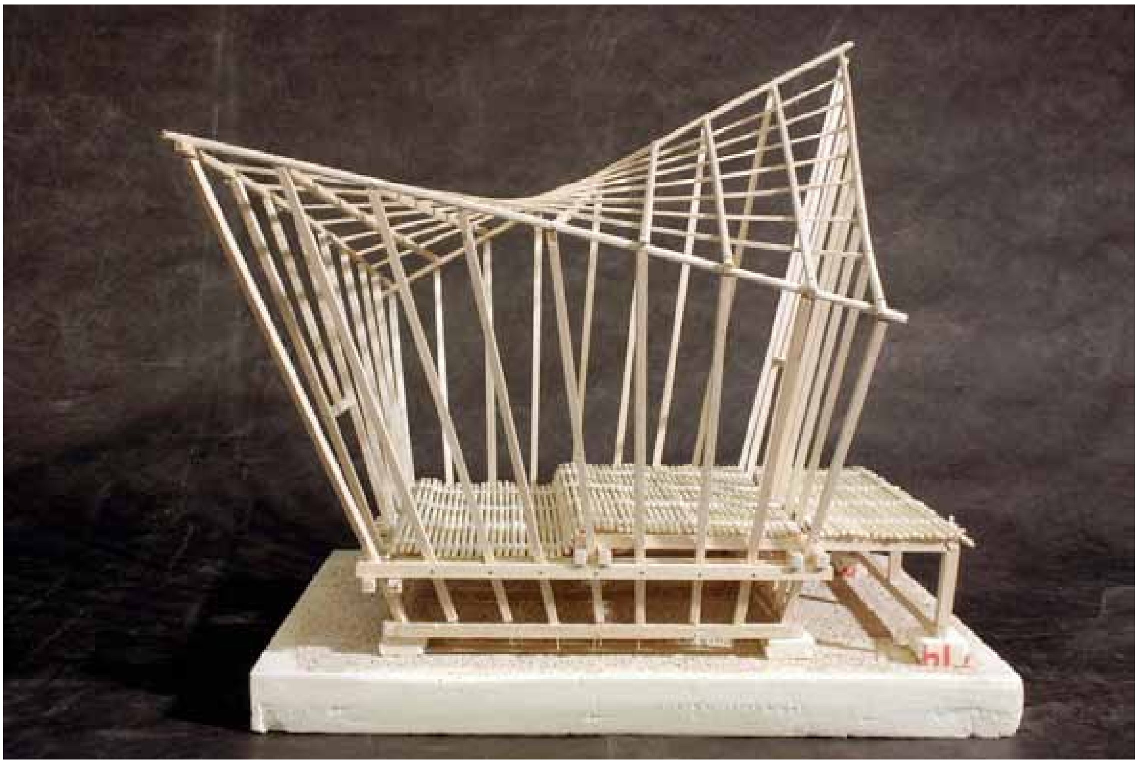

Figure 20: Project by Vera Kumer

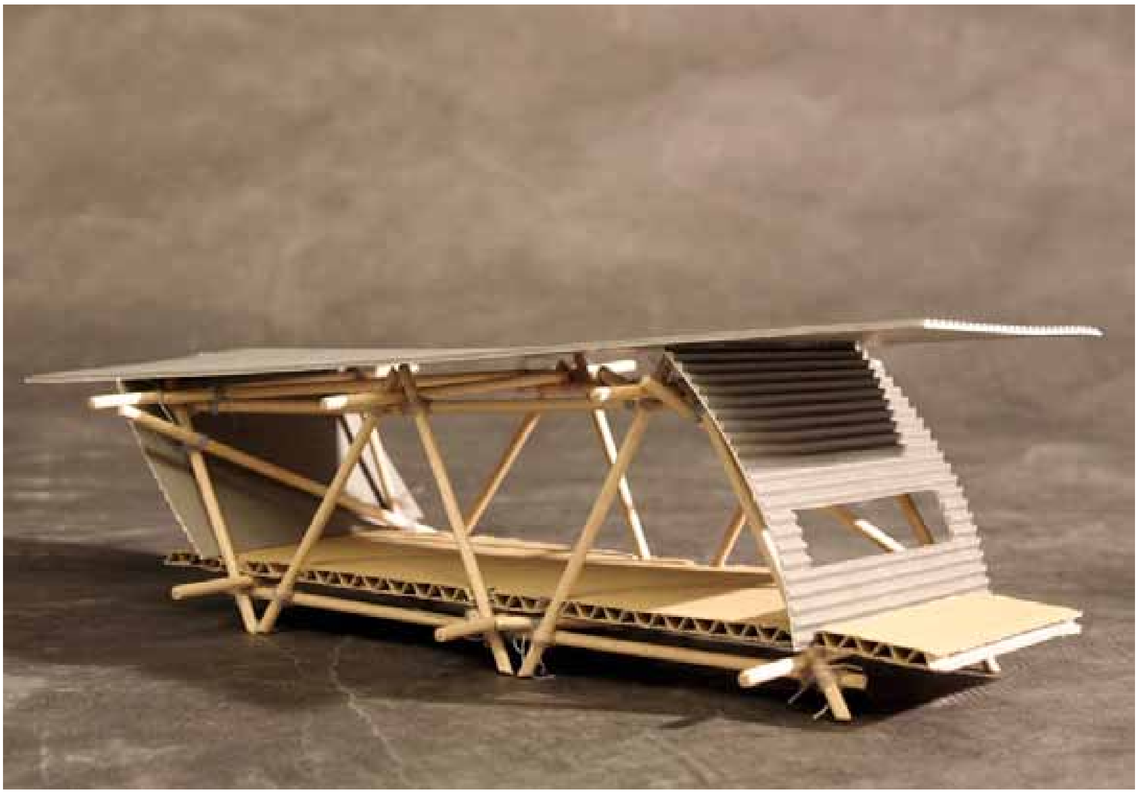

Figure 21: Project by Volker Leinich

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Title: Effectiveness and fallout of seismic retrofits in the traditional building cultures

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Abstract:

Over the centuries traditional and local building cultures developed a wide and varied range of design solutions able to withstand earthquakes. These solutions have been constantly improved just because of the repetition of disastrous events. Knowledge and understanding of the nature (and the reasons) of these techniques is essential if we want to protect the people, to improve their defences, or, indeed, to use, in different contexts, the guiding principles.

A first aim of our research on this topic was an initial cataloguing of different constructive cultures with the corresponding seismic devices, able to highlight the structural reasons for these choices. A comparison revealed the close relationship with the environment, with the availability of materials, with local cultures; it represents a needed step in order to identify weakness, effectiveness and improvement fields.

A further phase was based on an experimental validation through in-scale models (at University Laboratory, by tests on shaking table too), accompanied by analytical and theoretical studies in order to evaluate the effectiveness of such devices (structural interpretation).

Fallout of the work consists in an organized documentation and knowledge; in the dissemination and sharing of data; in the implementation of improvement practices (locally sustainable).

We began the search on these issues with specific reference to the earthen and masonry buildings, in Mediterranean cultures, in North-Africa and Near East.

We gained the belief that the structural behaviour of any "masonry" system is expression and function of the constructive culture that produced it and it cannot be investigated without a deep knowledge of the artefact itself and of the context that generated it.

Effectiveness and fallout of seismic retrofits in the traditional building cultures

Over the centuries traditional and local building cultures developed a wide and varied range of design solutions able to withstand earthquakes. These solutions have been constantly improved just because of the repetition of disastrous events. Knowledge and understanding of the nature (and the reasons) of these techniques is essential if we want to protect the people, to improve their defences, or, indeed, to use, in different contexts, the guiding principles. We gained the belief that the structural behaviour of any masonry system is *expression* and *function* of the constructive culture that produced it and it cannot be investigated without a deep knowledge of the artefact itself and of the context that generated it (MECCA & al., 2010; ROVERO & al., 2009; TONIETTI, 2011; ROVERO, TONIETTI, 2012; SANI, 2012).

Seismic retrofits in traditional building cultures

A first aim of our research on this topic consists on an initial cataloguing of different building cultures and of the corresponding seismic devices, in order to highlight the structural reasons for these choices. The study on the seismic behaviour of masonries highlighted the three fundamental goals required for the reinforcements applied to buildings exposed to earthquakes:

1. the construction of walls with a "monolithic" behaviour,
2. the implementation of connections among walls and among walls and horizontal elements with the aim to achieve the "closing" of the masonry box,
3. the implementation of isolating and/or dissipating systems

Techniques for achieving the first objective are: the "rule of the art" in masonry texture (importance of "diatoni", use of "listature", Fig.1); caging of stone roughly shaped blocks (Fig. 2); use of mortar that allows to obtain a good solidarity-connection among the blocks (Fig.3). The ways to achieve what described in item n°2 can be traced back to two fundamental techniques: the wooden chaining (that then will become metallic) and the wooden framework (Fig.4 and Fig.5). As regards the third item, meaningful solutions have been found in the historic monumental architecture belonging to the Ottoman influence (ROVERO, TONIETTI, 2012), characterized by the insertion of wooden devices in the pillar-arch systems (isolation) (Fig.6 and Fig.7) or inside the wall (dissipation) (Fig.8). In this context the works for the isolation of the foundations in the palace of Knossos are also mentioned, consisting in the placing of layers of sand and gravel (SPARACIO, 1999).

This survey revealed the close relationship of seismic-resistant devices with the environment, with the availability of materials, with local cultures (GAMRANI & al., 2011; OMAR SIDIK & al., 2011; FRATINI & al., 2011). In addition to the documentary value, the systematic cataloguing, made for different geographical, historical and cultural areas, represents a needed step in order to identify weakness (ROVERO, TONIETTI, 2008), effectiveness and improvement fields for the ways forward.

Experimental validation of traditional seismic retrofits

A second research line consists on an experimental validation through in-scale models at the Laboratory of Department of Architecture (DIDA, University of Florence), by tests on shaking table. The experimental

analysis is accompanied by analytical and theoretical studies in order to evaluate the effectiveness of such devices and to provide structural interpretation. In particular, in the field of masonry buildings, the question of the structural behaviour of an adobe building, strengthened by a wooden hooping device, has been investigated. The experimentation examined both the behaviour of single walls under in-plane horizontal actions and the response of the whole masonry box to seismic actions.

A study case has been identified in order to represent a large series of simple houses that are common in rural settings (Fig. 9). 1:5 scale panels, where wooden rods were inserted, have been subjected to Diagonal test (fig.10) and to dynamic test on shaking table, and compared with identical un-reinforcement panels. An 1:10 in scale model, representing a one-storey house, reinforced by three continuous wooden hoops positioned at different heights, has been subjected to dynamic actions through controlled frequencies and accelerations and then compared with the dynamic response of an identical un-reinforced model.

As regards the seismic behaviour of the panel, the presence of wood reinforcement does not produce an increase of the strength, while it improves the ability of energy dissipation and "restricts" the crack pattern. Looking at the crack pattern, it is possible to deduce that the presence of a wood element causes a break of the fracture dividing it into two parts (that does not affect the centre of the panel). The separation of the panel in sub elements through the insertion of the wooden elements produces fractures of low entities and prevents the formation of continuous diagonals fractures, dangerous for the structure.

As regards the masonry box, the seismic behaviour is greatly improved tanks to the wood reinforcement as demonstrated by the increase of the peak ground acceleration. While the un-reinforced house opened on the corners for low levels of acceleration and quickly collapsed, the reinforced box maintained its connections at the corners, exhibiting a crack pattern focused on the walls in parallel with the dynamic action and consisting in small diagonal fractures, limited to those parts of masonry ranging between the wooden rods, without reaching the collapse. In addition to this it became evident the role, isolating and dissipating, of the wooden elements.

An analytic evaluation, based on the application of the Limit Analysis to the masonry systems made by macro blocks (local damage mechanism) permitted to calculate the increase of strength offered by the reinforcement devices against the overturning of the walls subjected to the earthquake.

Conclusion

A first conclusion inferred from the carried out investigations allows to state that the traditional reinforcement techniques based on wooden hoops get, in the examined types, outstanding performance, using materials and technologies with low environmental impact.

Fallout of the work consists:

1. in an organized documentation and knowledge,
2. in the dissemination and sharing of data,
3. in the implementation of improvement practices (locally sustainable).

We began the search on these issues with specific reference to the earthen and masonry buildings, in Mediterranean cultures, in North-Africa and Near East, but it would be important to extend the testing and structural interpretation to a wider range of seismic devices present in traditional cultures.

Figures

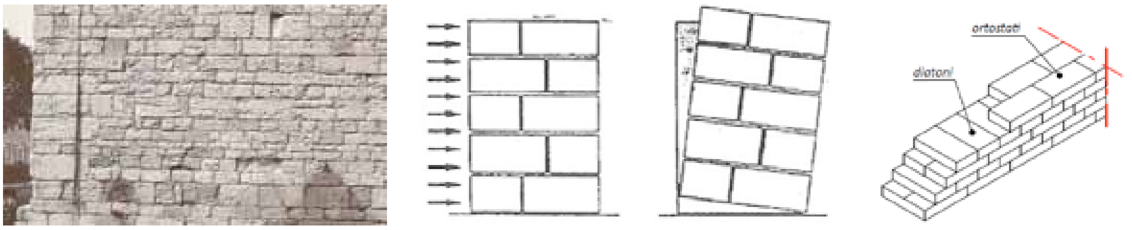

Figure 1: The “rule of the art”: the importance of “diatoni” (GIUFFRÈ, 1996)

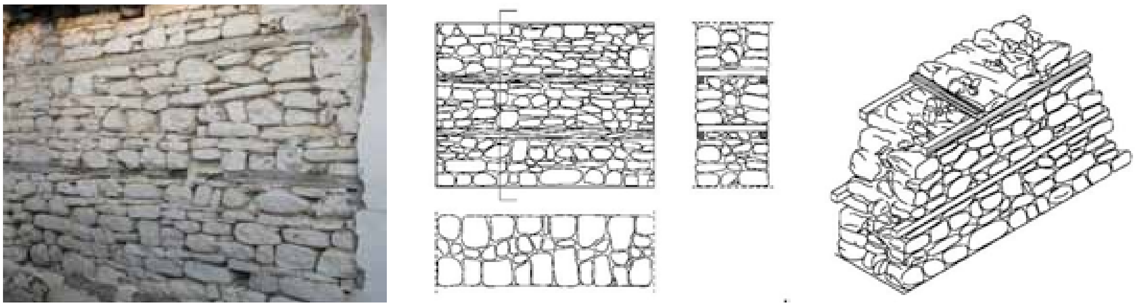

Figure 2 The Kalà of Elbasan (Albania), the original carrying out of the walls (MECCA & al., 2008)

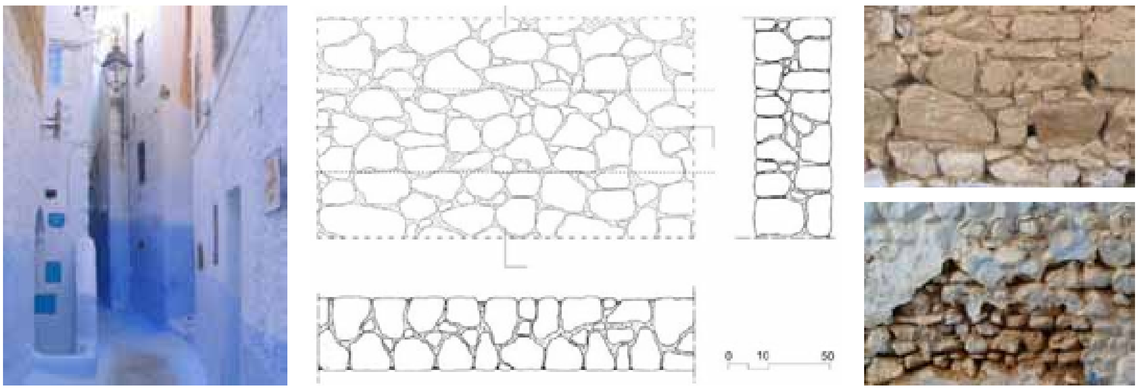

Figure 3: The Medina of Chefchauen (Marocco), analysis of masonry (CHADMI & al., 2007)

Figure 4: “Tac” construction technique in Scrnagar (Pakistan) and construction in Bhatar (India)

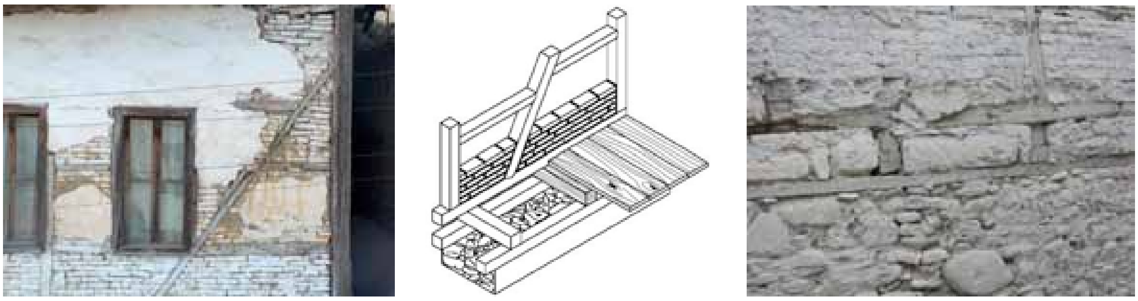

Figure 5: The Kalà di Elbasan (Albania), connection system

(a) (b) (c)

Figure 6: (a) Porch of Dey Palace, Algiers (Algeria); isolator above the capital (b) and at the haunches (c)

(a) (b) (c)

Figure 7: Examples of isolators: (a) Mosque el-Aqmar, Il Cairo; (b) Big Mosque, Kairouan, Tunisia; (c) Bimaristan Arghan, Aleppo

Figure 8: Dey Palace, Algiers (Algeria)

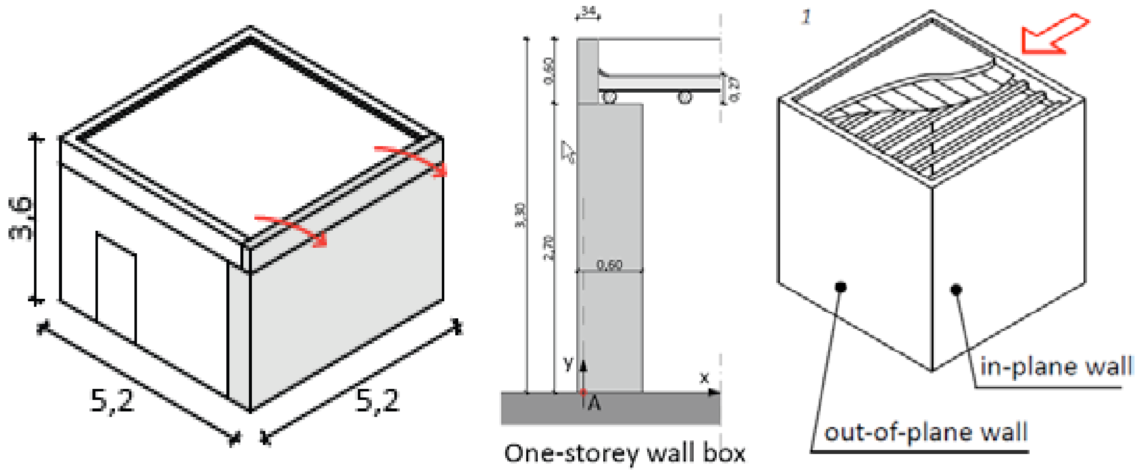

Figure 9: Study case

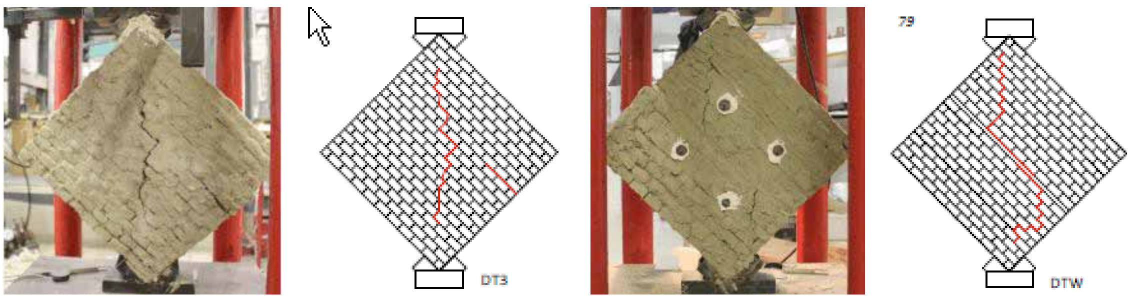

Figure 10: Diagonal tests of adobe panel and reinforced adobe panel

Figure 11: Adobe masonry box model: construction and shaking test

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Title: Earthquake bamboo architecture: make the house danse ?

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Abstract:

Bamboo is a building material used around the world. Simple to operate, its natural structure makes it resistant to traction and torsion. Full internodes, hollow structure, longitudinal fibers ensure superior wood mechanical performance, mass and / or volume equivalent. Rhizomes anchor the soil, reinforce river banks and limit landslides. Its harvest, carried out in a eco-friendly way by cutting the mature stalks only, preserves the bamboo forest. Its biomass increases from 10 to 30% per year, compared to 2-5% for a wood forest.

Its use enables to build large structures with local labors. Architectures can be of varied shapes, according to the housing needs. It offers excellent ductility: «houses can danse with the earthquake waves». This ability is a good seismic security identified by certain exposed populations. However, nowadays, there is no technical regulations for bamboo. Transmission of traditional construction techniques provides significant capacities of cheap accommodation. However, the implementation requires a good knowledge of nodes and connections. The evolution of technology, the introduction of exogenous materials and the transmission break of know-how require skills formalization. Scientific research is also required in order to certify the safety and guarantee the sustainability of these vernacular «non-standard» architecture. Environmental, nutritional and mechanical properties of the giant grass offer a high-tech rustic material.

Bamboo Architecture or how to make the houses dance?

Bamboo is used around the world to build suspension bridges, aqueducts, boats, floors, furniture and houses. Its daily uses evolve from traditional architecture to contemporary designs. This is an outstanding product of nature by its size, light weight, ease of implementation, rapid growth and delicate visual charm. In Asia, bamboo embodies both the most humble day to day life and the highest spirituality. It is a symbol of fertility, altruism and family happiness.

The bamboo composition

Density and speed of bamboo growth effectively fix carbon dioxide of the atmosphere, reducing the greenhouse effect responsible for global warming. The canopy of the bamboo forest maintains freshness and soil moisture. On the surface, the humus is made of fallen leaves each year. Rhizomes anchor soil, reinforce riverbanks and limit landslides.

Within two to four months, its rapid growth is due to the telescopic elongation of internodes enclosed in the bud. Firstly weak, the stem gradually lignifies and matures between three and five years. One year is sufficient for the manufacture of paper, against fifteen to thirty for pine and sixty years for oak. This rapid growth renews the resource without erosion of denuded by logging land. A 70 hectare bamboo allows the construction of 1,000 homes per year, the equivalent of 600 ha of forest if they were made of wood.

If dwarf bamboos cover the ground like weeds, others are 30 meters high and 30 centimetres in diameter. The rigid partition nodes and internodes strengthen their hollow stem. Tight longitudinal fibres give it its main qualities: flexibility, elasticity and high tensile strength.

The mechanical characteristics of “green steel”

The cut culms are ligated in lightweight boots and sent on carts or trucks. Often, the river carries bamboo rafts. This “floating” presents three advantages: low, it naturally sheds its starch and vehicle simultaneously men and goods. Before use, the bamboo is dried in a ventilated shelter during three weeks, twice as long for horizontal drying. Reduce the humidity around 12-15% can prevent the formation of fungi, increase strength, reduce weight and expansions. Heating bamboos over embers also helps straighten twisted bamboo.

Nicknamed “the steel plant”, this material is twice as strong as fibreglass and six times as light as steel which are the reason why it attracts the construction industry attention. Highly resistant to tensile and torsional strength, this plant circular section offers great flexibility which depends only on dimensions, not on the shape or direction of load application. Bamboo has superior mechanical performance compare to wood, mass and volume equivalent. Its density ranges from 500 to 800 kg / m^3. Its mechanical properties differ depending on the species, age, soil and climatic conditions, moisture canes and their lengths, but still excellent subjected to a force of compression or traction. Bamboo is tough but flexible. Before a possible rupture, its fibrous structure reveals the excessive constraints, which can be repair or consolidate. In terms of compression effort, bamboo competes easily with wood or steel.

Its most competitive property remains its price. The energy balance (MJ / m^3 N / mm^2) is very favorable: Steel: 1500; cement: 240; wood: 80; bamboo: 30. Creating a bamboo building requires 8 times less energy than cement and 50 times less than steel. Its life cycle explains the energy saving: culture without inputs, manual harvesting, transport and processing without heavy machinery.

Bamboo protects the environment

Thanks to the strength of bamboo, its solidity, its nature and its flexibility, its use for homes becomes essential for the contemporary economy and environmental protection.

Several factors determine the longevity of a bamboo house: choice of appropriate species, age and thatch construction techniques treatments. In sheltered areas, there are bamboo houses which are 35 years old, if the walls of woven bamboo are regularly maintained and whitewashed. In Java, 50 years old houses welcome three generations.

Prefabricated structures limit the transport of raw materials and workers. The fast erecting prefabricated kits are competitive. Factory prefabricated houses located in a rich bamboo site locally employs many people. Unlike mobile logging sites to find old trees, bamboo cutters are sedentary: time saving, pollution related to transport, maintaining the social fabric.

However, bamboo does not only have advantages. There are no two identical bamboos. If it is machined to make glulam beams, the joints between the elements are simple. But used in its entirety, to make the most of the natural qualities of stubble, there are problems with joins. It requires a specific knowledge of the workforce.

Construction techniques

Bamboo buildings enjoy several construction principles. Its lightness and flexibility facilitate its use for building's resistance to earthquake motions. Initially, in Colombia, mud walls were coated with a clay mortar, replaced by cement and sand in the 1930s to make facades embossed with bamboo slats. This technique gives the illusion of a house brick or concrete.

Nowadays, the Colombian Association of Earthquake Engineering opts for "bahareque" walls of bamboo or wood and bamboo, coated with cement mortar, supported by bamboo mats or netting. Protecting bamboos from UV and moisture prevents discoloration, deterioration and cracking. In France, some tests on bamboo panels' with the certification to European standards CAPEB program, show resistance till three tones of the fastening system.

As for wood or concrete poles, foundation blocks are connected to bamboo with steel. Such as wood and steel, reducing deformations involves innovations. Currently, the technique is to fill the stubble mortar at the joint and fix stubble by a parallel or vertical bolt. Researches of Colombian Jenny Garcon lead to recommendations for these joints. With each node filled with mortar, a parallel bolt resists till 7 kN tensile forces and to a vertical bolt untill 10kN.

Zeri Pavilion in Manizales, Colombia

A Manizales, poor families as wealthy families lived in houses of bamboo, syncretic architecture created by the merger between indigenous uses of bamboo and Spanish traditions of wooden construction and earth. The growth of "new urbanism" solves urgent problems using bamboo, inexpensive Aboriginal material. However, neglect of traditional techniques turns these new neighborhoods into symbol of poverty. The giant grass gradually loses its connotation of noble material.

Luckily, its enormous potential revitalizes the face of the crisis of natural resources. Her huge quantities can meet the needs of low cost housing. For Expo 2000 in Hanover, the designer Simon Velez and global network ZERI demonstrate its performance with Zeri Pavilion. This construction is the more firmly tested in the world: its walls are inclined to "dance" to the rhythm of the home land.

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Title: Learning from effects of earthquakes on vernacular architecture. Seismic damages investigation as key activity for disaster risk reduction

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Abstract:

In earthquake prone areas, learning from vernacular building cultures is not a «new idea”: their evolution during centuries attests of it. Even today, this learning process represents a great potential to further strengthen the resilience of contemporary societies dealing with seismic hazard. The proposed paper presents the results of a field study developed during the year 2012 in Macedonia. It focuses on the vernacular building typology in which horizontal timber elements are incorporated inside the main structural masonry walls: the «horizontal timber lacing masonry» building typology. The field study aims at better understanding the diffusion and implementation of this building typology. In order to learn about his seismic performance, particular attention is given to the practice of assessing building damages induced by a moderate earthquake M 4.5. The nature of the structure, the details and the materials implemented by vernacular builders, are relevant to the global resistance during horizontal shakings. The exploration of these technical aspects is useful for different reasons. In new contemporary architecture, they can be seen as a source of inspiration. In conservation activities, a better knowledge about vernacular technology may help to prevent - in a punctual and low cost manner - the natural and human phenomena that jeopardize the structural stability of these century-old architectural artefacts.

Learning from effects of earthquakes on vernacular architecture. Seismic damages investigation as key activity for disaster risk reduction

In areas prone to earthquake, a large part of the built environment consists of vernacular buildings, those implemented with techniques empirically developed during centuries and using mainly natural materials. Building techniques elaborated by vernacular builders are of several types and some of them have proven to perform adequately during earthquakes (LANGENBACH, 2009). In such a context, due to the heterogeneity of vernacular buildings - in their materials and techniques – it is central to investigate their seismic vulnerability by combining data collected before and after earthquakes and related to each existing vernacular building typology. This is important, as vernacular building typologies are multiple and as the details and the materials implemented by vernacular builders are various.

Among all existing building typologies, there is a particular wall typology that differs from others, be- cause until now it has been recorded only in the vernacular architecture of seismic areas: the wall typology whose specific feature is to have wooden horizontal element integrated into load bearing masonry. Noteworthy, this particular wall typology has frequently saved life of inhabitants during destructive seismic events (SUMANOV, 2003). Several building variables can be identified through the analysis of architectures corresponding to this wall typology that are located in areas with different levels of seismicity (in terms of Severity and Recurrence). For instance, referring to such a buildings existing in diverse regions along the North Anatolian Fault, the most evident variables are the type of masonry bonding and the masonry units size at the corners; the form of the horizontal elements - ladder-like or planks - and their vertical position in the wall; as well as the type of joints binding them together longitudinally – nailed plain or half-lap scarf joints - and at the intersection of perpendicular walls – halved corner joint or halved corner joint with double dovetail. Starting from identified building variables, a typology can then be subdivided into various typological sub-types. A particular sub-type of the wall typology considered here can be defined as follows: double-wall masonry bonds type made of rubble stone combined with ladder-shaped horizontal timber elements. This advanced categorization is helpful for further specific structural analysis, as for example, the investigation of buildings after an earthquake. The ladder plays a key role in order to grasp the nature of the influence that building variables have on the seismic performance of a typological sub-type. In fact, post earthquake reconnaissance helps to identify the factors that are likely to increase or to re- duce the seismic vulnerability of buildings. In this way, critical - positive or negative - factors related to each building variable can be investigated. Following this approach, a post earthquake investigation was performed in Beltchichta village in the North area of Ohrid Lake (Republic of Macedonia). Beltchichta is situated 9 km away from the epicentre of a moderate 4.5 Magnitude earthquake that occurred the June 07, 2012 (hypocentre at 1 km depth). In that occasion, the post seismic reconnaissance has led to some remarks about the influence of the vertical position of horizontal elements and the timber joint types. In some buildings, stones in the masonry walls have been over- thrown due to out-of-plane movements (figure 1a). This generally occurred in the higher parts of the constructions. This failure mechanism appears to be reduced when the height of masonry between the two upper horizontal timber elements is minor and if

(a) (b) (c)
Figure 1a and Figure 1c. Seismic damages on two different buildings in Beltchichta Village (Republic of Macedonia). Figure 1b. Undamaged building in Beltchichta Village (Republic of Macedonia). Credits: M. Hofmann.

the roof rafters are imbedded between two horizontal timber elements situated at the top of the wall (figure 1b). In some cases, a disconnection also occurred between horizontal timber elements. This happened mainly in the lower part of the building and in conjunction with weakened nailed plain or half-lap scarf joints. These connections lost their binding efficacy over time and were unable to support these new seismic forces: previous earthquakes, wood rotting, nails rusting can be considered as the major causes of this new state of vulnerability. Related to this specific seismic effect, it is interesting to record that in a particular case a masonry wall cracked vertically exactly where this type of disconnection occurred (figure 1c).

In general, highlighting the aspects influencing the vulnerability of vernacular architecture through the investigation of building typologies and their respective typological sub-types, has a dual interest. Firstly, it facilitates a structured identification of very specific critical factors likely to be related to seismic risk. Secondly, it fosters a better understanding of the dynamic behaviour of each typo- logical sub-type, allowing for more accurate hypotheses. Besides, when combined with findings resulting from experimental laboratory tests focusing on vernacular technology, the critical factors identified during field-based empirical investigation - and the ensuing hypotheses about seismic performance - constitute useful references for ordinary architectural activities. Mainly, for building processes in which architects and engineers don't play any active role. All these reference data - based on real behaviour of buildings - could be regrouped into general and/or specific guidelines regarding the specificities of each building typology characterising vernacular architecture, also taking into account the differences that can exist between their local variants. Hence, two major issues become apparent vis-à-vis of the role of this type of guidelines. On the one hand, architectural references become a source of technological inspiration for new contemporary architecture, as for post-disaster reconstruction projects (SCHACHER 2008). On the other hand, in heritage conservation, a deeper knowledge of vernacular practices helps stakeholders to prevent natural phenomena - such as materials deterioration - and human phenomena - such as architectural modifications - that can dangerously reduce the structural performance of existing built environment (SAHINGUCHAN, 2007). Thus, if learning from vernacular building cultures is not a "new idea" - their evolution during centuries attests of it - this learning process still represents a great potential nowadays, first and fore- most, for the strengthening of the resilience of contemporary societies that have to deal with seismic hazard.

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Title: Seismic vulnerability of traditional rural Haitian houses made of timber frame with earth infilling

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Abstract:

The present study is funded by the French national research agency (ANR) through the call for project proposals "Haiti Earthquake - for a sustainable reconstruction" that followed the devastating earthquake of 2010. It is conducted in collaboration with the CRAterre / ENSAG laboratory and aims at providing support to the Haitian authorities and international non-profit organizations that help locally, offering construction methods based on constructive traditions in rural Haiti. These traditional timber framed houses with earth infilling showed good resistance to earthquake but the development of methods for the prediction of their resistance, thanks to numerical modelling and experimental validation, is necessary to prove their correct aseismic behaviour and optimise their design by means of choices appropriate to the social context and for a sustainable construction.

A multi-scale analysis is proposed (scale of joints, scale of walls and scale of the house). Tests performed at each scale are presented. At the scale of the house, a shake table test was performed on a traditional house with an accelerogram considered as representative of the 2010 Port-au-Prince earthquake with a peak acceleration of 0.3g. The house did suffer no damage during the test. The house was then submitted to the same earthquake amplified at 300%. Important damages could be observed but the house did not collapse.

These test results will be used for supporting local authorities and non-profit organizations in promoting traditional constructions. The test results will also be used for the validation of numerical models that aim at predicting the structural response of this kind of construction submitted to an earthquake.

Keywords: timber-frame structures, earth, stones, infilling, seismic resistance, hysteretic behaviour , multi-scale approach, shear walls

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Seismic vulnerability of traditional rural Haitian houses made of timber frame with earth infilling

The 2010 Haiti earthquake has shown the lower vulnerability of traditional Haitian houses compared to urban concrete constructions. The aim of the presented study is to analyse the seismic behaviour of traditional Haitian timber-frame houses infilled with natural stones and earth mortar in order to predict their seismic resistance and optimise the constructive systems used for post-earthquake reconstruction. Timber-frame buildings are characterized by the use of metal fasteners in which dissipation phenomena are mostly localized. Thus, three scales are defined, the joints (scale 1), the structural elements (shear walls, scale 2) and the building (scale 3). This paper focuses on the experiments performed at each scale. At scale 3, a dynamic test was performed on a full scale house by means of the shake table of FCBA Institute at Bordeaux.

Introduction

During the earthquake that struck Haiti, on the 12th of January 2010, a great number of concrete block and reinforced concrete buildings were heavily damaged. The destruction or collapse of these buildings had a dramatic impact in terms of human life and huge economical loss for the country. In urban areas as well as in rural ones traditional timber frame buildings did not suffer that much, showing an enhanced structural behaviour and exposing their inhabitants to a limited risk, thanks to their lower seismic vulnerability.

These findings raise the issue of the very limited importance given to local architectures by the scientific community and by those responsible for reconstruction, despite the fact that in Haiti as well as in other places, those structures have often shown highly relevant use of technical solutions and available resources, in relation to the constraints and the potential of the context.

Within the framework of the ReparH project, supported by the French National Research Agency (ANR), a scientific collaboration was established between researchers in the field of architecture (CRAterre, Ecole Nationale Supérieure d’Architecture de Grenoble) and engineering (3SR Lab, Université Joseph Fourier – Grenoble 1) with the Haitian organization GADRU, to carry out a technical and methodological reflection to support the development of sustainable reconstruction and vulnerability reduction strategies.

This paper presents the analysis of a building system used for housing reconstruction and based on the use of materials such as earth, stone and timber (Fig. 1). Timber-frame structure with masonry infill is studied at multiple scales, ranging from that of joints (scale 1), that of the structural element (shear wall or shear wall elementary component), and the whole building (scale 3).

This approach is proposed for modelling purposes. It is based on the assumption that the non-linear dissipative phenomena are concentrated in joints. It makes possible to test several parameters such as the influence of the type of nails in joints or the influence of the infilling type In addition, it gives experimental data for the identification and the validation of models at each scale (RICHARD & al., 2002).

Figure 1: Traditional Haitian timber-frame house

5- Description of the specimens and experimental set-up at the scales of joints, shear walls and the whole structure

5.1- Joints (scale 1)

A typical joint is presented on Fig. 2. It is a steel-wood nailed connection made by a punched steel strip that embraces the wood parts (T shape) and is fixed by some nails. Currently, only smooth ones are used in Haiti for wooden structures but the use of ringed nails has also been investigated.

The punched steel strips are usually used in Haiti. On-site, those parts are anchored in the basement wall made by natural stones and cemented by concrete mortar.

Wood dimensions and classes are chosen in order to correspond to local wooden members characteristics.

One test under monotonic loading and one test under alternate cyclic loading were performed for each joint configuration (Tab. 1). The loading path was adjusted thanks to the ISO standard (2010) (Fig. 3). Tests are displacement controlled.

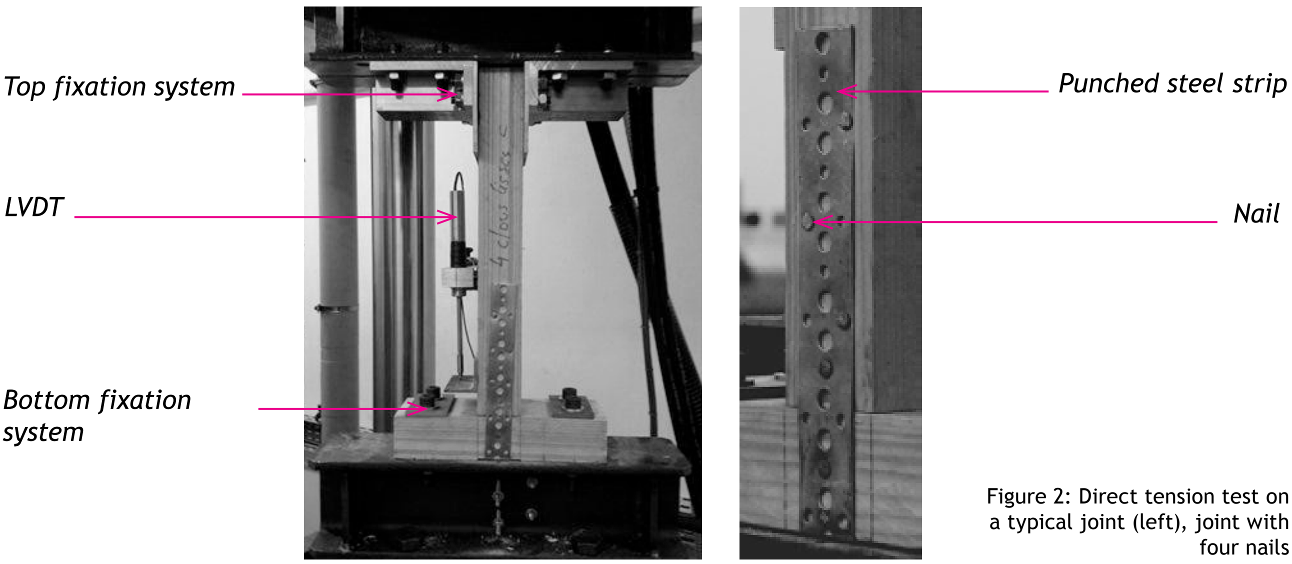


Figure 2: Direct tension test on a typical joint (left), joint with four nails

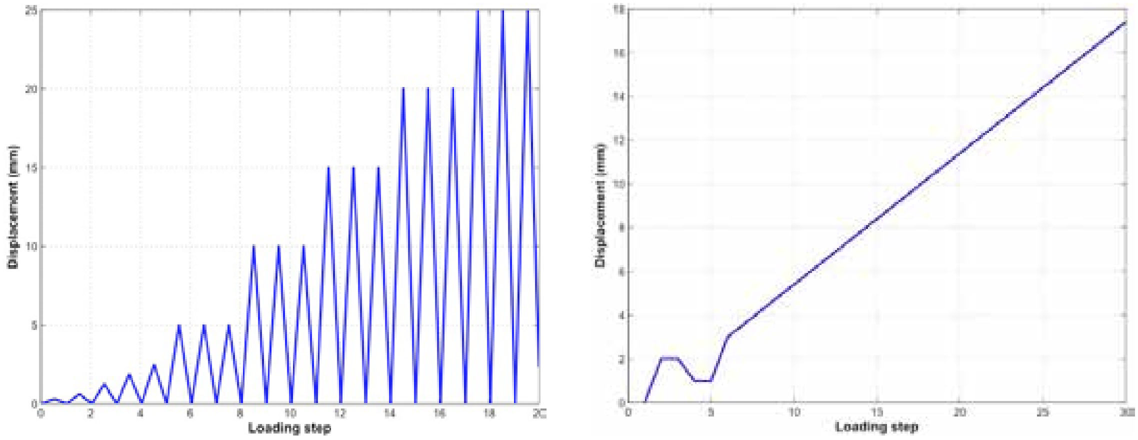


Figure 3: Joint test protocols under cyclic and monotonic loading

Number of nail	Nail (mm)	wood section (mm)	Wood mechanical class
1	2.5x70 smooth	50x100	C18
2	2.5x70 smooth	50x100	C18
4	2.5x70 smooth	50x100	C18
2	3.0x50 ringed	50x100	C18
4	3.0x50 ringed	50x100	C18

Table 1: Configuration of direct tension test on joints

5.2- Shear walls (scale 2)

Infilled timber-frame construction is traditionally used in rural areas due to its low cost (earth and stones are available on site). There are three main kinds of structures: braced by Saint Andrew’s crosses filled with natural stones linked by an earth mortar (Fig. 1 and Fig. 4), braced by one diagonal per elementary wall filled with adobes (handmade earth brick) and braced by cob panels. The first type of bracing is chosen because of its construction ease and its current use in Haiti.

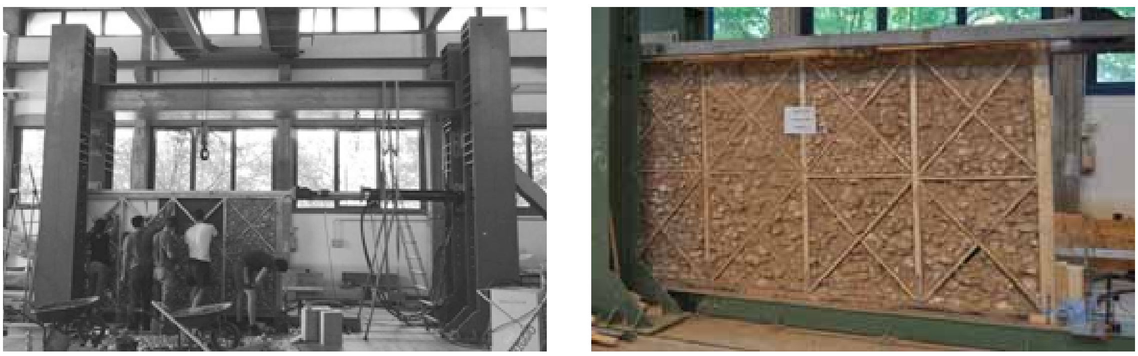


Figure 4: Push over test on a infilled timber-frame shear wall

The test shown on fig. 4 was performed in august 2011 at CNR Ivalsa in Trento, Italy because of the experience of this institute on tests on the same kind of filled timber-frame structures (CECCOTTI & al., 2006). The filled walls were built directly on the testing apparatus because of the difficulty to move them (ALI & al., 2012). Therefore, after wall construction, it has been covered with a plastic tarpaulin and a dehumidifier has been used to dry quickly the earth mortar (h=30%, T=20-25°C). In this way, mortar dried in three days only. To prevent cracking, water content was limited in earth and natural fibres were added. The earth was composed by one measure of a clay-calcareous mix (grading < 125 µm), two measures of sand (grading < 2 mm), half-measure of water (depending of sand's water content) and one measure of sisal fibres. The clay-calcareous mix was chosen in order to have a mortar as similar as possible to the one made with local earth.

The fibres limit cracking apparition and growth in mortar. Smooth nails are put inside wood triangles to improve the earth-wood link. The wood characteristics and the dimensions are identical to the ones presented in Tab. 1 except for extremity posts which have a 100x100 mm cross section in order to support vertical loads. The loading protocol is chosen according to ISO standard (2010) (Fig. 5). The

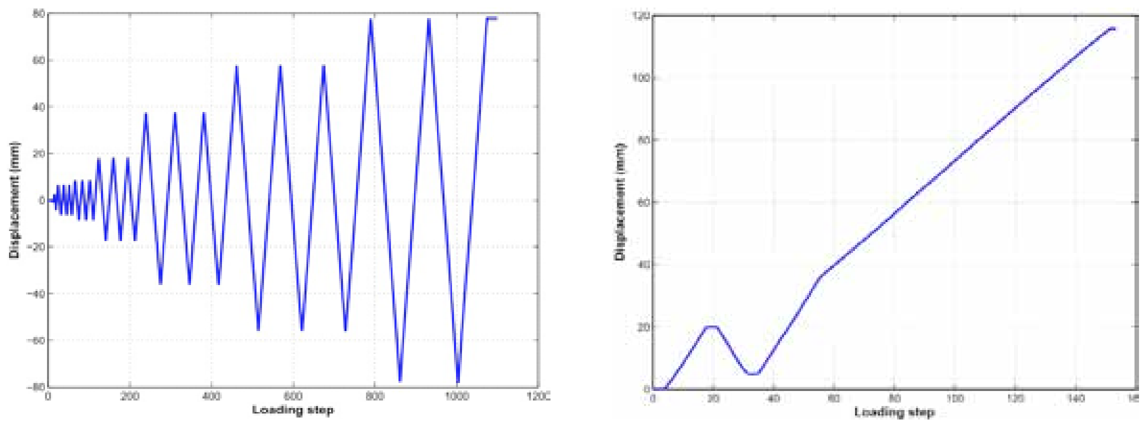
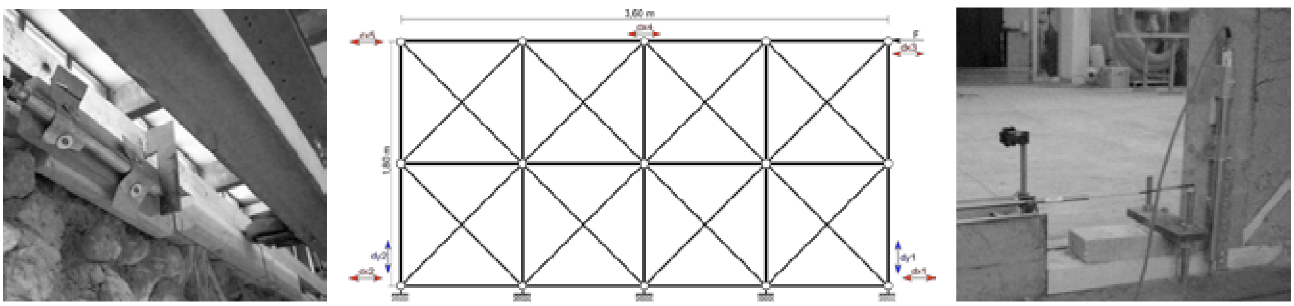


Figure 5: Shear wall test protocols under cyclic and monotonic loading



(a) (b) (c)

Figure 6: (a) anti-buckling system, (b) displacement measurements, (c) LVDT at the lower extremity of the wall

Number of tests and type of loading	Infilling	Nail/joint
1 monotonic/2 cyclics	Stones	4 smooth 2.5*70
1 monotonic/2 cyclics	empty	4 smooth 2.5*70

Table 2: Configurations of shear wall tests

top wall displacement is controlled at a rate of 2,2 mm/s. The bottom horizontal wood beam is anchored (Fig. 6). Vertical and horizontal displacements are measured at each extremity of the wall (Fig. 6b, 6c) and buckling of the wall is prevented thanks to rollers (Fig 6a). The roof of traditional Haitian houses is very light, therefore no vertical load is applied on the wall. Tab. 2 presents the characteristics of the tested shear walls. The shear wall presented in Fig. 4 was also tested dynamically by means of a shake table (see 2.4).

5.3- Elementary wall (scale 2)

Traditional rural Haitian houses are built in different ways described in 2.2.1. In order to optimise the aseismic feature of different construction systems, a specific device has been designed to test elementary walls that constitute the global shear wall (Fig. 4, 7, 8). The bottom beam of the elementary wall is embedded. The loading protocol is similar as the one used for the shear wall (Fig. 5), the top displacement is controlled a linear variable differential transducer (Fig. 8c).

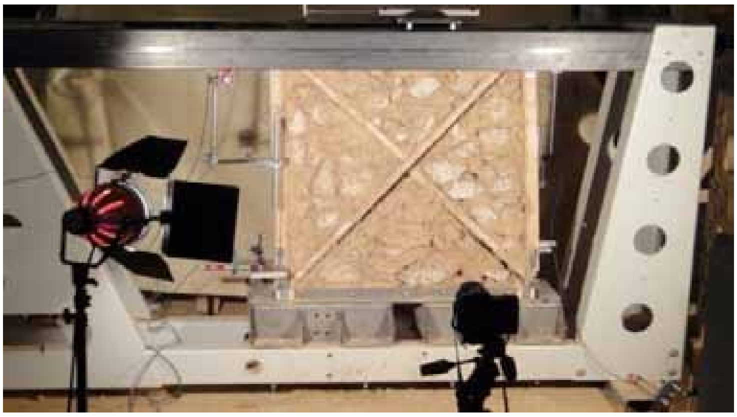
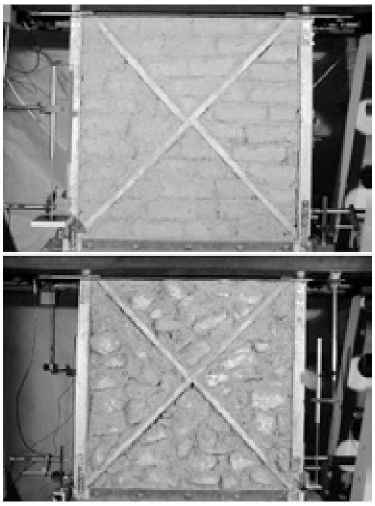
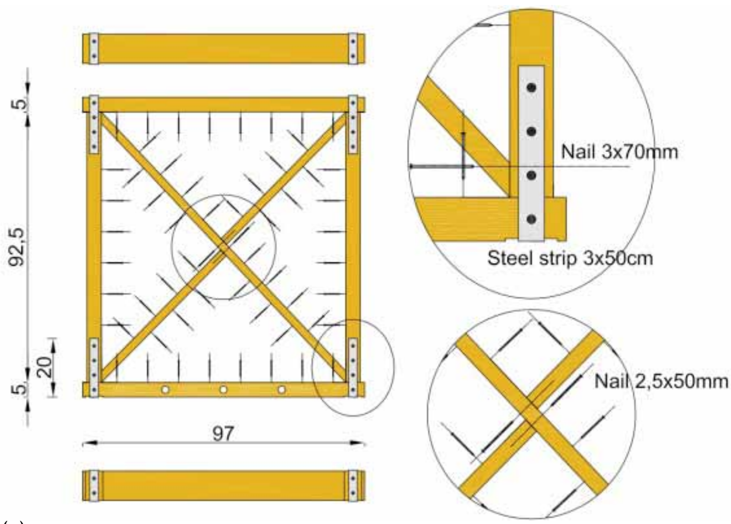


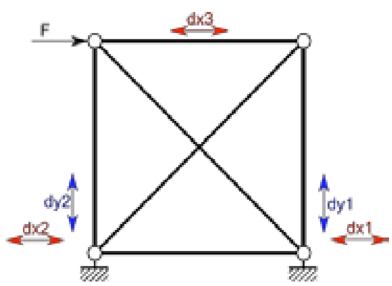
Figure 7: Shear test on elementary wall



(b)



(a)



(c)

Figure 8: Empty elementary wall configuration (a), elementary wall filled with adobes (top) and stones (bottom) (b), displacement measurements (c)

Tab. 3 presents the characteristics of the tested elementary walls.

Number of tests and type of loading	Infilling	Nail/joint
1 monotonic/2 cyclics	stones	3 smooth 2.5*70
1 monotonic/2 cyclics	adobes	3 smooth 2.5*70

Table 3: Configurations of tests performed elementary wall tests

5.4- The whole house (scale 3)

Figure 9: Full scale traditional Haitian timber-frame house with earth and stones infilling tested at FCBA Bordeaux

A shake table test was performed at FCBA Bordeaux by means of a 6m x 6m table specially designed for timber frame structures (Fig. 9). The structure is symmetrical and the ground acceleration is unidirectional. Because there is no record of the 2010 Haiti earthquake accelerogram, two synthetic or modified natural accelerograms were used:

1. Haïti: a synthetic accelerogram considered as representative of a possible earthquake at Port- au-Prince (Fig. 10) ;
2. Guadeloupe: a modified natural accelerogram considered as a possible earthquake in the French Caribbean island Guadeloupe used for the revision of seismic hazard maps for French regions. The acceleration response spectrum is close to the standard response spectrum of Eurocode 8 (1998).

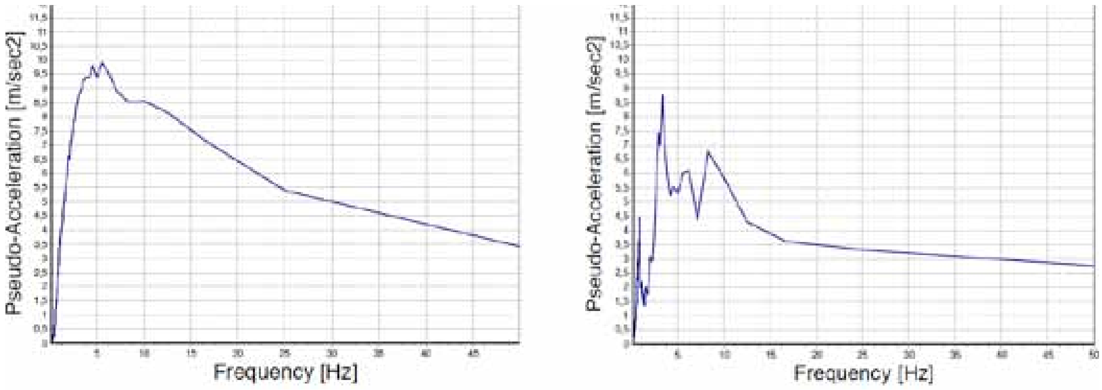


Figure 10: Acceleration response spectra for Guadeloupe (left) and Haiti (right) earthquakes

6- Results

6.1- Connections

Results of direct tension tests on joints can be seen on Fig. 3.1. and are summarized in the Tab. 3.1.. The main test results will be shown during the seminar.

7- Conclusion

This paper presents a multi-scale experimental program in which connection, elementary wall (part of the wall) and a whole wall were tested intensively under quasi-static conditions. In addition some shake table tests were performed on a shear wall and a full scale house.

Acknowledgement

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Title: Distressed Urban Fabric, Disaster Resistant Building Culture and Development Animators

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Abstract:

Present day distressed urban fabrics are on the most part associated with inner city pockets of poverty or marginal / informal settlements. Poverty is a multi-faceted phenomenon that can manifest itself as deprivation from a combination of various necessities afflicting human well-being ranging from that of economic health / nutrition unsuitable / lack of shelter. The inhabitants of distressed urban fabrics are on the most part poor and their «shelter» is on the most part structurally vulnerable. When such urban settings are geographically situated in disaster prone regions of the world, the matter of structural integrity of shelter achieves an acute significance, the lack of which is of grave concern.

Community-based disaster risk management as opposed to top down approaches has achieved wide-spread acceptance within development circles since the 1980’s and 1990’s as a viable approach to promoting culture of prevention in the pre-disaster phase of risk assessment and mitigation. Yet, over the years, the dynamics of institutionalizing CBDRM within underprivileged communities and in the policies, planning and implementation of local authorities has proven to be a significant challenge.

Promotion of a disaster resistant building culture can go hand in hand with the promotion of participatory urban planning approaches to rehabilitation of distressed urban fabrics. Intermediate development non-government organizations active within distressed urban fabrics have played a crucial role in systemizing platforms of dialogue between authorities and communities while tackling a myriad of issues through community empowerment approaches.

It is proposed that development animators and facilitators should also be called upon to sit next to research stakeholders, policy makers and users in the quest for «new» frontiers of research and thus implementation methodologies.

Reza SHEIKH

Distressed Urban Fabric, Disaster Resistant Building Culture and Development Animators

> *"We are proud people. Please respect our integrity and do not take away our self-confidence. Grant permission to us people of Bam to take the reconstruction of our city and our lives into our own hands and help us to rebuild Bam the way we want. These are not only my words, this is what all the people of Bam request."*

Zahra, Bam Resident and Earthquake Survivor – member of audience during a gathering of community members, city and district officials, and NGOs six months after the earthquake.

Background

The city of Bam located in southeast Iran was practically obliterated by an earthquake on Christmas Eve 2004. We were among the over one hundred and seventy national and international NGOs who had flocked to the city. We faced a horrifying human toll and a demolished adobe garden city. It was a grand detour from our usual working grounds - urban pockets of poverty, and we were not sure how we would use what we had learned through the years as advocates of community empowerment approaches to poverty alleviation. We were an intermediate development NGO comprised of a staff of development animators facilitating participatory local development planning and implementation, wherever authorities would allow[1]. Iran is a disaster prone country; as such mother earth (sadly) paved the way for us to take part in other cases of post-disaster reconstruction over the following years. Soon the acronym Community-Based Disaster Risk Management (CBDRM) found its way into our mission statement next to Community Empowerment (CE) and Community Driven Development (CDD).

Drawing upon our experiences in distressed urban fabric, this brief note is a discussion of how CBDRM can be promoted through participatory urban planning particularly in a pre-disaster planning phase.

Community Empowerment and Urban Poverty

> *"The complex institutional context of the city means that expertise and impact on poverty is not held exclusively by any one institutional actor. This creates complexity in program planning and implementation as well as providing powerful opportunities for institutional change. In this way cities are different from isolated rural areas where often one line ministry, a large NGO or a peasant federation may hold sway over development work. Successful partnerships have the potential to influence the institutional framework in which attempts at poverty reduction on a city wide scale can take place, although this is not often achieved."*

(SAHLEY, PRATT, 2003 : 99)

Literature abounds with in depth academic, empirical and even philosophic studies on the topics of community development and community empowerment. Fact is every practitioner in the field, after a few years of experience, will be able to deliver his/her definition of these intertwined concepts[2]. Simply stated, the community is the basic

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1 *Hamyaran Local Development Resource Center (www.hamyaran.org).*

2 *The definitions stated here on draw on various resource papers written by Hamyaran's Chief of Board, Mohammad Baquer Namazi.*

unit of development management decision making. It is enabled to get organized, define its potentials and problems, articulate its needs and priorities and make decisions within the community and local context. Through its elected members the community participates in studies, planning, implementation and monitoring and assessment of all programmes and interventions affecting its members and their environment.

This approach should be defined through the eyes of the poor people and not that of researchers and national and international development "experts, technocrats or bureaucrats". Without this change in perspective, the minimum danger is that the approach becomes paternalistic and is adopted with its meaning and content drained by the State and its organizations. People have the natural instincts of survival and development. These skills and instincts are stifled. Hence, enabling or empowerment or participation of the community means that structural constraints on the community are removed so that its inherent capabilities, talents and energies are released for community development management and decision making, particularly decision making and planning, resource mobilization, resource allocation and priority setting and determining the future of its members.

Poverty is a multi-faceted phenomenon that can manifest itself as deprivation from a combination of various necessities afflicting human well-being ranging from that of economic > health / nutrition > unsuitable / lack of shelter. The interventions of NGOs active in the field of urban poverty and local urban development planning at large have been summarized in the box below.

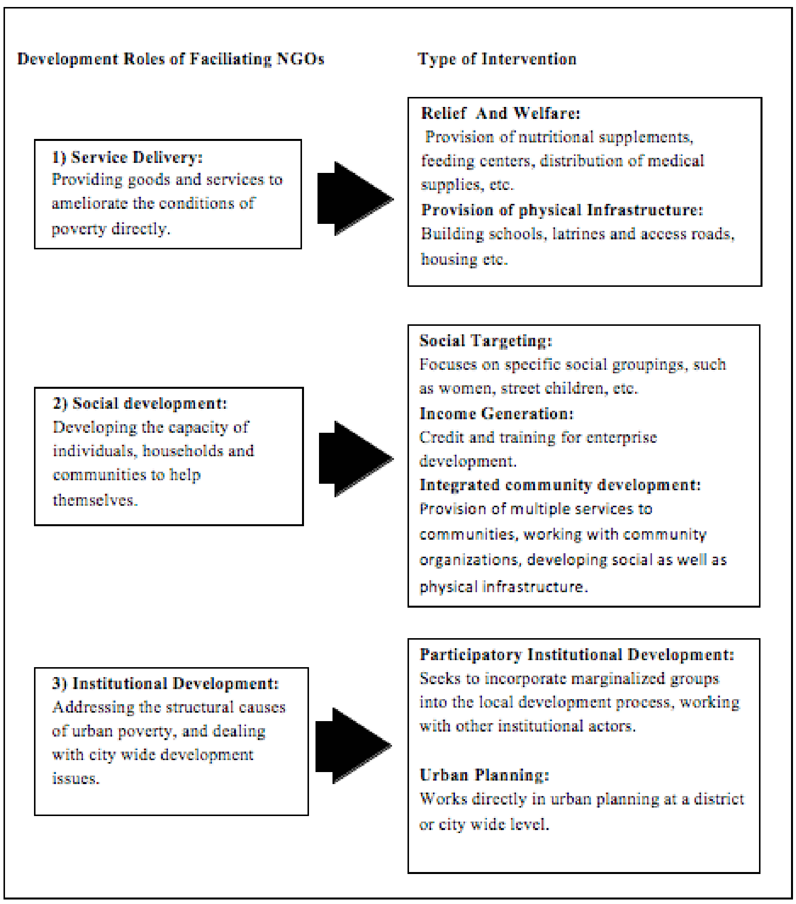

Figure 1: Sahley and Pratt (2003 : 99)

The city arena is best fit for promoting participatory projects engaging local community / neighbourhoods, local municipality officials, local central government sectorial offices, and civil society organizations around the professed needs of the target communities. The communities through their representative bodies must develop capacities to sit and tap into their local wisdom and extract their common professed needs. They must be able to muster enough social transparency and coherence among themselves to rally their common pool of energies around fulfilling their needs through the cooperation of all government and non-government bodies sharing their concerns of development. Social inclusion in decision making processes at the community level, the ability to formulate desires into text, documenting community gatherings, becoming aware of means and channels of communication with responsible officials are among other capacities that are built through the agency of development NGOs or trained development animators non-government or government alike.

City officials must be supported by law and official stipulations to incorporate a transparent decision making process where local community decisions are received and acted upon through means available to them. Not all issues can be solved or needs be met through municipality resources. The central sectorial offices have their own resources that can be channelled to the community level. Traditional charity organizations with an amazing ability to mobilize considerable funds and who have their already existing extended network of basic service deliveries. In the most part in developing countries the private sector is either missing or weak. Local private sector, local small and medium enterprises have a crucial role to play as sources of employment generation.

It is in the city arena where decentralization can begin most meaningfully and immediately. Delivery of services can be delegated to local agency as a first step and it is here that specialized action NGOs can step forward alongside other CSOs to assume responsibilities. It is trust building and promotion of dialogue at the grass roots and face to face between people, their organizations and their government. The challenge lies in the ability to harmonize these removed and separate initiatives at the local level. A local development framework is required.

The main stakeholders within the city arena are on the most part the community, the local government (governor or district manager, the municipality, city council, office of informal settlements) and the de-concentrated sectorial agencies (different central government local offices). The local development framework systemizes the interaction between the stakeholders around community professed needs.

Shelter Vulnerability and Community Driven Development

Present day distressed urban fabrics are on the most part associated with inner city pockets of poverty or marginal / informal settlements. The inhabitants of distressed urban fabrics are on the most part poor and their “shelter” is on the most part structurally vulnerable. When such urban settings are geographically situated in disaster prone regions of the world, the matter of structural integrity of shelter achieves an acute significance, the lack of which is of grave concern.

Community-based disaster risk management (CBDRM) as opposed to top down approaches has achieved wide-spread acceptance within development circles since the 1980’s and 1990’s as a viable approach to promoting culture of prevention in the pre-disaster phase of risk assessment and mitigation. Yet, over the years, the dynamics of institutionalizing CBDRM within underprivileged communities and in the policies, planning and implementation of

local authorities has proven to be a significant challenge. Community- Driven Development (CDD), with the right resources and the drive of motivated civil society facilitators / development animators, can bring immediate community action at a time when institutional and structural (and perhaps legal) reforms can be a long and tedious process.

Within the city confines and its immediate surroundings, pockets of poverty (inner city or marginal) must receive specific attention particular to the boundary conditions within each "settlement". Intermediate development non-government organizations active in distressed urban fabric can play a crucial role in systemizing platforms of dialogue between authorities and communities, facilitate the formulation of a local development framework, while tackling a myriad of issues through community empowerment approaches. CBDRM can be one such concern.

Promotion of a disaster resistant building culture during a pre-disaster planning phase can go hand in hand with the promotion of participatory urban planning approaches to rehabilitation of distressed urban fabrics. Community members are called upon to take part in researching the structural pathologies of their "homes" and "public buildings" within a larger revitalization development framework, while engaging in a participatory urban planning exercise with municipal authorities. As such a data-base is formed in a participatory manner urban block by urban block. The final data can be analysed by a "disaster resistant building knowledge centre" established by outside experts within the neighbourhood. The "experts" in turn report their findings to the urban block residents, step forward to promote appropriate construction codes, while tapping into and endorsing local knowledge and traditional construction practices. A disaster resistant building culture can only be arrived at through sustained activity of community members in the form of active research, planning and building within the local public arena. It is through the interactive community workshops facilitated by development animators that capacity is built for the various stakeholders, while interests are kept alive with the passage of time by the facilitating development NGO. It is therefore proposed that development animators and facilitators should also be called upon to sit next to research stakeholders, policy makers and users in the quest for "new" frontiers of research and thus implementation methodologies within the realm of disaster risk management.

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Theme 3 : The social demand and the contributions human and natural sciences

Title: Ethnoecological contributions to the study of disaster-resistant building cultures: the case of cap-haïtien, Haiti

Authors: Lea GENIS, Anthropologist, researcher

Institution: CRAterre-ENSAG laboratory, Grenoble

Country: France

Abstract:

Within the ReparH (building back safer in Haiti) research program1 and a Master's degree internship of the French National Museum of Natural History2, an ethnoecological field study has been completed in Cap-Haïtien city, Haiti. One among the objectives was to complete the ways forward on disaster-resistant building cultures, while developing a methodology which could combine the "ethnoecological" and "construction cultures" approaches. The town of Cap-Haïtien is an historical city characterized both by recurrent hazards (floods and fires) and over-publicized upcoming risks (earthquakes and tsunamis). It offered therefore a special context related to these concerns. The research has focused on the expressions of local construction cultures, housing, body of knowledge, know-how and representations related to the built environment and natural hazards.

Lea GENIS

Ethnoecological contributions to the study of disaster-resistant building cultures: the case of Cap-Haïtien, Haiti

Within the ReparH (building back safer in Haiti) research program[1] and a Master's degree internship of the French National Museum of Natural History[2], an ethnoecological field study has been completed in Cap-Haïtien city, Haiti. One among the objectives was to complete the ways forward on disaster-resistant building cultures, while developing a methodology which could combine the "ethnoecological" and "construction cultures" approaches. The town of Cap-Haïtien is an historical city characterized both by recurrent hazards (floods and fires) and over-publicized upcoming risks (earthquakes and tsunamis). It offered therefore a special context related to these concerns. The research has focused on the expressions of local construction cultures, housing, body of knowledge, know-how and representations related to the built environment and natural hazards.

Conceptual framework

At the confluence between social and natural sciences, ethnoecological approach focus on the study of Traditional Ecological Knowledge (TEK): cumulative body of knowledge, know-how, practices and representations involved in the multiples interactions between human societies and their environment (NAKASHIMA & ROUE, 2002). While depending on intangible learning processes, TEK embody in the material activity of building. Ethnoecology enables to describe them, along with an analysis of vernacular categorizations concerning housing, building, materials, and natural or social hazards (FRIEDBERG, 1974). It can also bring forward the way people memorize risks and question the transference and redesign of associated knowledge and skills.

Indeed, when considering the notion of risk, we have to question its conceptions, which are both linked to objective quantifications and socially constructed, through memories and personalities, towards events distinguished by their uncertainty (BOTTERILL & MAZUR, 2004). Natural events or hazardous situations are moreover experiences embedded in social life, and impact memory, perceptions, individual and collective practices (OLIVER-SMITH, 1996 ; REVET, 2011). The questions raised are the following: What can create an "event" locally. How do we live with risk, that is to say both with its memorial construction and with the many ways it is appropriate and used? What are the practices related to these conceptions and the strategies constructed to prevent damages ?

Methods applied for data collection

Within the field study organized in Cap-Haïtien, traditional tools of ethnology and technical anthropology have been selected, together with the methodology developed by CRAterre (GARNIER & al., 2011 ; CAIMI & al. 2013). These tools help to analyse disaster- resistant building cultures, tanks to a combination of observation and interviews with the stakeholders related to construction (inhabitants, builders, institutional stakeholders) (Table 1).

Methodology must be not prescriptive, as it is not intended to impose a setting to the field, but to deduce the principal issues, and to help unattended categories to emerge. It implies a deep immersion on the field, which is the only way to contextualize the related observations and discourses, so as to understand representation systems in which disaster-resistant building practices are included.

1 A scientific collaboration between CRAterre, the National School of Architecture of Grenoble (ENSAG) and the Joseph Fourier University (UJF) supported by the French National Research Agency (ANR) to provide scientific support to Haiti (July 2010 - January 2014).

2 Environnement, Développement, Territoires et Sociétés, spécialité Anthropologie de l'Environnement, département Hommes Natures Sociétés du MNHN.

Theme 3 : The social demand and the contributions human and natural sciences

Tool	Proceeding	Sample	Goals
Systematic observation	. Observation checklists, . Record sheets, . Pictures.	. Houses, . Construction sites, . Urban context.	Completing accurate and comparable surveys : - Disaster-resistant building techniques - Operational sequences
. Participant observation, . Informal talks.	. "Being involved", live with people, . "perceive, memorize, note" . Question the practices noted with the informants.		Understand : - Social structures, interactions, technical processes and their context of production, - What cannot be verbalized: embedded know-how and skills, transmission processes… - How do people « live with risk »
Semi-directive interviews	. Interview guidelines, . Audio recordings, . Transcripts, . Discourse analysis, . Thematic review.	. Officials, . Builders, . Inhabitants.	. Understand the meaning actors give to their practices, the ways of justifications and expectations, . Highlighting unidentifiable categorizations, . Understand how memory and conception of risks are expressed = have a representative view of the social context, with interconnected interviews to understand the relationships and interactions.
Focus group	. Debate, . Debate guidelines	About 10 persons interested by the topic	. Understand the background of major risks and events, places and sites, . Emphasize the interaction, . Understand how collective discourses can be built around natural hazards, opposing point of views, . Bring together news ideas and opportunities.

Table 1: Tools used for the ethnoecological study of disaster-resistant building culture in Cap-Haïtien (may 2012)

Sample of results in Cap-Haïtien

Along the analysis of field data, different points of interest have emerged related to the study of disaster-resistant building cultures in Cap-Haïtien.

Local appropriations of risk (LANGUMIER, 2008) have been noted, associated with different values related to the notion of « risk ». The survey shows how risk is linked with different corpus of justifications (natural hazard, blaming of the institutions or of the carelessness of the inhabitants). He can also be included in power plays between inhabitants and public authorities, or later move to revalue ancient built heritage, seen as safer thanks to its durability and presume resistance towards time and disasters. This value of durability emerges also when analysing the categorizations and expectations related with building materials and techniques: they lead to an ethic of mineral and strength, rooted in practices and representations.

Once that risk categorization has been understood, we are able to examine how they are included in the construction practices. For instance, we can consider the evolution of houses construction, and note the emergence of disruption points, linked with natural events, and translated into technical shifts. In Cap-Haïtien, the progressive depreciation of wood for heavy masonry in bricks, rubble stone and eventually concrete blocks is not only linked to an aspiration to « modernity », but to the protection against the potential damages caused by fires and cyclones. More recently, the earthquake of 2010, even if it did not happen directly in the city, led to a new disruption point, affecting the overvaluation of the strength associated with concrete. In a context highly submitted to international technical influences, the valuation processes are to maintain a "rigidity approach" towards seismic construction, which become the focus point of constructive expectations.

Some tools for the analysis of disaster-resistant building cultures?

These early results show how ethno-ecological approach of disaster-resistant building culture enables us to understand the way actors seize natural hazards and risks, both in the social and technical sense, through the input of complex system of knowledge that are sometimes difficult to describe through systematic observation only. It reminds us to take a closer look at the production environment of constructive practices, which are often in tension between local appropriations and global need of formalization.

However, in order to have a clear understanding of these elements, ethnological study requests a long term immersion on the field. Immersion that is sometimes as difficult to formalize as the knowledge studied itself. In implies therefore a constant reflective and critical exercise on analysis and data production setting, so as to be able to report them in the final presentation. Thus, the time needed for the survey can sometime mismatch with operational objectives in short term. Nonetheless, it seems to be essential to understand the various and subtle features that characterize building cultures.

Eventually, the results of this work should be even more accurate when included in an interdisciplinary study than would link both the ethnological and architectural approaches, so as to describe precisely as much technical processes as the representation systems they are included in. Hence, this interdisciplinary work would help develop new models of analysis, find solution to match research agendas and open the ways forward to worth exploring routes.

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Theme 3 : The social demand and the contributions human and natural sciences

Title: L'ordre des choses et l'ordre du monde : aspects psychosociaux et environnementaux de la (re)construction du sens post-catastrophe

Authors: Ludvina Colbeau-Justin, chercheuse associée

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Abstract:

Les perturbations sociales et individuelles consécutives aux catastrophes naturelles sont multiples, affectent les routines et l'organisation de la société, provoquent des stress individuels et collectifs. La prise en charge classique de ces catastrophes majeures se fait essentiellement à travers une aide d'urgence, visant à subvenir aux besoins immédiats. En revanche, la psychologie environnementale met en avant une approche différente pour la planification des risques, basée sur la prise en compte des facteurs psychosociaux et des pratiques spatiales dans un environnement chaotique. L'observation systématisée de comportements de remise en ordre de l'environnement apparaît alors comme un enjeu pour le relèvement des populations au même titre que la prise en compte de la satisfaction incontournable des besoins primaires. Ces comportements de remise en ordre visent à redonner un sens physique, psychique et symbolique à l'environnement, et apparaissent comme nécessaires à la reconstruction active de l'univers individuel des sinistrés, préalable à la reconstruction d'une réalité et d'un monde nouveau. Vivre dans une zone sinistrée suppose ainsi la mise en place de processus individuels et sociaux d'adaptation, notamment pour réduire et contrôler les incertitudes. Ces processus remodèlent le rapport aux autres et à l'espace, dans le but de restaurer un sens, une signification à la réalité quotidienne. Cette contribution s'appuie sur les résultats de recherches menées après des inondations majeures et des séismes. En termes de réponses sociales, malgré l'existence de comportements déviants (comme des pillages rapidement stigmatisés), les expressions altruistes et de solidarités sont majoritairement observées. Les comportements altruistes et la mobilisation sociale apparaissent comme une stratégie de faire face efficace : par exemple, la recherche ou l'apport de support social, l'investissement dans des activités militantes ou des actions d'amélioration du cadre de vie, le renforcement du tissu social. Un renforcement des processus identitaires et le sentiment d'appartenance à un territoire et un groupe social s'affirment. En termes de pratiques spatiales, la modification du rapport à l'espace mène à d'immédiates tentatives de réappropriation de l'espace. On observe alors des gestes qui peuvent sembler dérisoires face à l'ampleur des destructions, comme l'action symbolique d'une jeune lycéenne accrochant sur un pan de mur effondré son diplôme scolaire, ou la personnalisation décorative d'abris temporaires. La réappropriation des lieux de pratiques quotidiennes se réalise dans le temps avec la restauration des routines, et dans l'espace, à travers des marquages symboliques ou la création d'espaces sociaux transitoires (lieux de culte). Elle vise à redonner aux espaces et aux lieux un sens connu, à ré inscrire des pratiques identitaires et des modes de vie structurants. Ces processus, qui doivent être conçus comme interdépendants, sont autant d'éléments modulateurs du relèvement individuel et de la société car ils participent d'une remise en ordre et en sens du monde, aux échelles individuelles et collectives. Ils peuvent agir comme des ressources ou des contraintes en fonction de leur intégration et de leur reconnaissance dans une réflexion sur l'amélioration de la réponse sociale post désastre.

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Theme 3 : The social demand and the contributions human and natural sciences

Title: Ethnoecological contributions to the study of disaster-resistant building cultures: the case of cap-haïtien, Haiti

Authors: Annalisa Caimi, Architect EPFL, DSA “Earthen Architecture”

Institution: CRAterre-ENSAG laboratory, Grenoble

Country: France

Abstract:

In areas prone to recurrent natural hazards, coping strategies developed by local inhabitants and builders take a great variety of forms. Although technical type of measures, embedded into buildings since their construction, are the most obvious, other measures including temporary technical devices and specific behaviours can significantly contribute to reducing the vulnerability of the built environment of a community. Moreover, those different solutions are often a balance between locally existing skills, resources and risks and are meaningful of the vulnerability level accepted, case by case, by the inhabitants in relation to these factors.

The identification and recognition of the diversity of these disaster-resilient practices can be extremely valuable for the enhancement of local resilience, through the development of a variety of options to reduce building vulnerability, in adaptation to different technical and economic capacities existing within a community.

Based on experiences conducted in Bangladesh, in the framework of a disaster preparedness and risk reduction program, and in Haiti, in the 2010 post-earthquake context, this paper suggests some considerations with regard to the necessary conditions under which local construction practices can be considered since an essential phase, that of their identification, analysis and understanding. These experiences are related to the development of a methodology for the analysis of local building practices in risk-prone areas aiming to understand the features and different aspects of constructive strategies developed by local builders while combining contextual factors influencing the architecture and resilience of communities living in areas affected by different types of natural hazards.

Exploring disaster-resilient local building practices as starting point for vulnerability reduction strategies

In areas prone to recurrent natural hazards, local communities have often integrated local risks into their daily practices, developing singular techniques, construction details and devices to prevent and/or to reduce the vulnerability of the built environment (FERRIGNI & al., 2005). Although measures of technical type are the most obvious, other measures including temporary technical devices and specific behaviours can significantly contribute to decrease the exposure of a community. Representing a balance between local existing skills, resources and risks, these practices have demonstrated their relevance over time and during particular events (BAUMWOLL, 2008; LANGENBACH, 2009). Identifying, understanding and taking into account these strategies can be extremely valuable in building resilience through habitat sector. In particular, extending the analysis of local constructive practices beyond the building scale can enable to apprehend various strategies developed by builders and inhabitants of vernacular architectures, which may play a determining role into the vulnerability reduction process of existing and future built environments.

A tool for investigation

In the framework of a PhD thesis in architecture at the CRAterre-ENSAG, laboratory a particular methodology has been developed for the analysis of local building practices in risk-prone areas. This qualitative tool aims to understand constructive approaches developed by local builders as well as factors influencing the architecture and the resilience of communities living in regions affected by different types of natural hazards. This work has been based on an iterative approach of design, experimentation, verification and adaptation, through field-testing related to two different situations: 2010 post-earthquake context in Haiti and disaster preparedness in Bangladesh. The developed methodology focuses on four main aspects:

- the natural and built environment, including the physical, climatic, geological and morphological features of the territory,
- buildings, as a response to needs, desires and activities of their inhabitants but also as the result of a particular combination of technologies and materials,
- knowledge and know-how, combining the experience and comprehension developed by a group of people in shaping their habitat and in dealing with challenges that it presents,
- available resources, including building materials, economic and technical capacities to create and to continually evolve a built environment as well as to prepare and respond to crises.

Based on a participatory-driven approach (CHAMBERS, 2007), this methodology takes into account as sources of information the existing buildings, but also individuals and groups involved in their design, implementation and maintenance. In fact, builders, artisans and inhabitants are considered as the holders of specific knowledge and information needed to understand the reasons behind certain particular technical solutions.

The analysis implementation is structured into different phases, based on collective and individual discussions, technical analysis and the use of specific graphic tools, leading to the acquisition and verification of information from multiple sources. The resulting findings provide the starting point for the development of technical, methodological and operational principles that may contribute to improve technologies known locally and to support existing dynamics.

Discovering disaster-resilient local building practices

On the basis of this methodology, experiences conducted in the framework of a disaster preparedness and risk reduction programme[1]1 in Bangladesh, and housing reconstruction and improvement activities[2]2 in Haiti, have highlighted the great variety of solutions implemented by local population to reduce the building vulnerability to various types of natural hazards.

Vernacular builders have indeed conceived a multiplicity of strategies that may vary from hazard to hazard, from region to region, and even between members of the same community, ranging from territorial management to constructive detail. In fact, in addition to protective measures at the level of the surrounding area (such as a vegetation barrier as protection from high winds or particular plantation to stabilize riverbanks and hillsides), different types of devices are used to reduce vulnerability at the building level.

Technical measures of permanent type are integrated into the building since its construction, through details and constructive provisions calibrated to the recurrence and severity with which natural phenomena locally occur. In Khulna region (Bangladesh), a sacrificial earthen mass is used at basement level to preserve the stability of the bearing structure during seasonal floods. Furthermore, the characteristics of local floods have determined the particular double step shape of the plinth: the lower step matches the level of the most frequent floods, limiting possible necessary repairs to this small part; the second step is sized in relation to the level of exceptional floods (Fig. 1). In Haitian West department, some vernacular constructions are characterized by a gradual reduction of the wall thickness and the use of lighter materials on the upper portion, minimizing the risk of serious injury to occupants in case of a partial collapse of the walls (Fig. 2).

According to this type of measures, sometimes a single device can improve the structure behaviour to multiple hazards. In Haiti rural areas, the low height of the vernacular houses helps to enhance wind resistance and, as their centre of gravity is lowered, their resistance to seismic loads is also increased. Similarly, horizontal bracing at four corners of the wall plate strengthen the structure of wooden frame houses against annual strong winds, but also to less frequent hazards, such as earthquakes.

Moreover, some architectural elements beyond a functional and aesthetic purpose may also assume a structural function. In Haitian vernacular houses, timber planks placed between the wooden posts to fence the veranda act as cross bracing: even if the lower masonry wall collapses, the structure maintains a relative consistency and a complete collapse is prevented (Fig. 3). In the same way, the decorative friezes adorning the gables help deflect the wind flow and thus minimize depressions likely to tear off roofs (Barré et al. 2011). However, technical measures to reduce the vulnerability of buildings may also be momentary and temporary, without influencing the main structure. Indeed, they may be implemented just before a foreseeable hazard (e.g. cyclone or flood) and subsequently withdrawn, or they may be done using materials and techniques that provide fast replacement with very little economic and technical effort. These

1 « Construction of Pilot Low Cost Houses (LCH) Project for the Disaster Affected Families of Bangladesh », jointly implemented by Caritas Bangladesh, the Bangladesh University of Engineering and Technology and CRAterre-ENSAG, and funded by Secours Catholique-Caritas France and Caritas Luxembourg (2011-2014).

2 Programmes implemented by Haitian organizations from the Plateforme d'Agroécologie et Développement Durable (PADED), and supported by Misereor (Germany) and CRAterre-ENSAG. Activities related to the analysis of local building cultures have been carried out in the framework of ReparH-ANR research project (2010-2014).

types of provisions, apart from being easily implemented by the inhabitants themselves, are also cost-effective solutions to reduce, at least in part, vulnerability to local hazards, especially for those who are not able to afford more efficient or perm anent measures. In the villages of Assassuni sub-district (Khulna region, Bangladesh), exposed to cyclones with annual frequency, tiled and thatched roofs are covered by fishing nets or bamboo grids and the roof structure is fastened with ropes to trees or stakes driven into the ground, to prevent them from flying off (Fig. 4).

In addition to such technical devices, other measures have also been developed, going beyond the merely technical dimension and corresponding to that of practice and behaviour (Dekens 2007). In Gaibandha district (Dinajpur region, Bangladesh), houses located on the Jamuna River banks are built with very light materials. During exceptional floods occurring every 2-3 years, people dismantle their houses and temporarily move them to a safer place. These buildings are therefore designed to be quickly and easily disassembled, moved and reassembled by the inhabitants themselves.

(1)

(2)

(3)

(4)

Figure 1: Hashkhali (Khulna region, Bangladesh): double step earthen plinth for erosion control.
Figure 2 and 3: Grande Rivière (West department, Haiti): reduction of thickness and weight of the wall; bracing on the veranda.
Figure 4: Thakurbad (Khulna region, Bangladesh): connection of the roof structure to stakes driven into the ground.
Credits: A. Caimi.

Building local resilience capabilities

The results of these analyses highlight the variety and relevance of solutions developed by local people in relation to each particular environment. However, they also bring out the need to integrate this diversity into methodological and constructive proposals aiming to enhance local resilience capacities. In post-disaster phase as well as in preparedness and prevention activities, such an investigation provides the basis to improve local technologies through a diversification of solutions, proposing a range of options tailored to different socio-cultural situations and investment capacities as well as integrating local potential, constraints and coping strategies.

On one hand, the analysis of local building practices, included into programme activities since their beginning, provides the essential information to identify and implement particular measures to improve existing buildings and construction practices. In Bangladesh, this approach has led to develop different technical solutions for preventive housing improvement and methodological strategies for disaster preparedness and response, according to the features, risks and resources specific to each region.

On the other hand, this phase may contribute to enhance local and international stakeholders' capacities to manage future crises and to undertake long term vulnerability reduction measures. In Haiti, this analysis allowed to gather useful information for the ongoing post-disaster programs. But especially, through awareness and training, this activity contributed to enable local actors, involved in reconstruction as well as working in areas not affected by the 2010 earthquake, to develop a project approach for housing improvement and vulnerability reduction on the basis of existing practices and resources.

Understanding construction and coping practices developed by local populations and, at the same time, recognizing local knowledge and expertise thus become a real starting point to enhance resilience at multiple levels and on the long term.

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Theme 3 : The social demand and the contributions human and natural sciences

Title: Improvement of rural housing for disaster prone areas in Bangladesh: experience of Caritas Bangladesh.

Authors: Jyoti F. Gomes, Director, Disaster Management and Development

Institution: Caritas

Country: Bangladesh

Abstract:

Bangladesh is known as one of the most disaster prone countries in the world due to its geographical location. Floods, cyclones tidal surges, landslides, tornadoes, riverbank erosion, drought and earthquakes are very common in Bangladesh. Shelter is one of the basic rights of the people of Bangladesh. Seventy five percent households of Bangladesh live in poor and unhygienic shelters. Caritas Bangladesh as a human development organization has been constructing shelters i.e. Low Cost Houses (LCH) for disaster-affected families since 1970. An evaluation report for shelter construction program for cyclone Sidr (in 2007) affected families indicated for more integration of the local technology, culture and practice with the technical solutions for shelter construction. Then Caritas involved CRAterre and Bangladesh University for Engineering and Technology(BUET).

A Pilot Low Cost House (LCH) project was initiated in 2009 in two different context flood and cyclone prone areas funded by Secours Catholic/Caritas France. Based on the lesson learnt, a three year extended project covering the whole country started in 2011 co-funded by Secours Catholic/Caritas France and Caritas Luxembourg. A thorough local survey involving community people and artisans is carrying out for understanding the local building culture. Initial design of LCH is developing considering the testing of available locally materials and technical analysis of the structure including cultural, social, environmental and economical aspects. Houses are constricting after validation of community people, local artisans and the beneficiaries on the initial design.

Housing projects under Caritas Bangladesh are benefiting from the results of the pilot project. The paper will present on the learning of the past and ongoing Pilot LCH Projects.

Keywords: Community participation, hazard, risk reduction and housing improvement.

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Theme 3 : The social demand and the contributions human and natural sciences

Title: Development of Disaster Resistant Housing in Bangladesh

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Abstract:

Bangladesh is known as one of the most disaster prone countries in the world due to its geographic location and socio-economic condition of people. Flood, cyclone, tidal surge, land slide, river bank erosion, draught and earthquakes are common natural disasters in Bangladesh. In recent years, these have caused extra burden for the marginal people of the country and jeopardizing its economic growth as a whole. Although it is a small country, its culture, disaster, availability of building materials are diverse and the housing practices are also widely varied. Lots of houses are damaged due to disasters on a regular basis and cause the most economic losses. Government and NGOs provide housing to the disaster affected people. However, constructions of these houses often do not respect local culture and sometimes constructed in highly vulnerable locations. At the same time there is a lot to learn from existing vernacular houses even they lack technical adequacy. Different international guidelines are also available for a number of years. A question may naturally be asked: why are these not being followed in practice? The answer is that R&D does not focus enough on local practice and that the fruits of existing R&D are not being transferred into the field as these houses are mostly designed and built by owners or artisans who do not have access to these booklets. Current codes also do not have provisions for disaster resistant rural house design. Obviously, there is a necessity for bridging this gap by learning from the people and then, transferring back the improvement to them. Input of local people, local artisans, and local culture should be considered for wide acceptability. A two year project has recently been completed to design and construct houses in cyclone and flood prone areas of Bangladesh. To develop the design of the house at first, the local practice and availability of local materials were studied. Besides, it was considered essential to understand and accommodate the need and culture of the community. Three-stage community level meetings were held to collect views of the people along with the local artisans. Properties of the local construction materials were ascertained from laboratory tests. Considering the service and environmental loads, designs were finalized based on Finite Element Method (FEM) analyses. Model houses were constructed at the selected locations to demonstrate them to the local community with an aim that new design or at least some features would be replicated. Performances of these model houses are being monitored. Based on the experience obtained from this project, a further extended project is being carried out in six different geographic locations of Bangladesh. This paper presents the experience of the completed project.

Keywords: Community participation, Disaster resilient, Local Material, Local Building Culture, Rural Housing

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Development of Disaster Resistant Housing in Bangladesh Considering Social and Cultural Issues

Introduction

Bangladesh is known as one of the most disaster prone countries in the world due to its geographic location and socio-economic condition of people. About 50% of the land is within 6-7 m from Mean Sea Level (DMB, 2008). Common disasters of Bangladesh are flood, cyclone, tidal surge, land slide, river bank erosion, draught and earthquakes. In recent years, these have caused extra burden for the marginal people of the country and jeopardizing its economic growth as a whole. Although it is a small country, its culture, disaster, availability of building materials are diverse and the housing practices are also widely varied.

House is one of the basic needs of human beings. It is a pity that majority people of Bangladesh live in non- engineered (83%) and unhygienic housing. The main cause of substandard housing is poverty. Lots of houses are damaged due to disasters on a regular basis and cause the most economic losses during disasters (DMB, 2008).

Government and NGOs provide housing to the disaster affected people. Some are very costly and strong enough and some are very nominal and temporary. However, constructions of these houses generally do not respect local culture and sometimes constructed in highly vulnerable locations. After the construction of external agency led houses, it is rare that the community replicates the same design. In 2007, a super cyclone Sidr (velocity= 242 km/hr and tidal surge height= approx. 5m) passed through Bangladesh and damaged lots of houses. In response to that cyclone many houses also were constructed by government and NGOs. However, as can be seen from the photograph of the Figure 1 that many houses were constructed in paddy field which lacks both local practice and technical knowledge.

Different international guidelines are available for a number of years. At the same time there is a lot to learn from existing vernacular houses even they lack technical adequacy. A question may naturally be asked: why are these not being followed in practice ?

The answer is that R&D does not focus enough on local practice and that the fruits of existing R&D are not being transferred into the field as these houses are mostly designed and built by owners or artisans who do not have access to these booklets.

Current codes also do not have provisions for disaster resistant rural house design. There is a gap among the responding agencies for not having an effective design and technology for the construction of LCH.

At the same time, each of the community has their own construction techniques and materials for LCH. Some of them are very effective and scientific. These are sometimes overlooked during the construction of LCH. There is a gap in understanding the local knowledge for having effective design and technology for the construction of LCH.

Obviously, there is a necessity for bridging this gap by learning from the people and then, transferring backs the improvement to them. Input of local people, local artisans, and local culture should be considered for sustainability. To this context, a two years project has been completed in Bangladesh.

Figure 1. Construction of houses after the cyclone Sidr 2007.

1- Project Background and Objectives

Caritas Bangladesh (CB) as a human development organization constructing shelters i.e. Low Cost Houses (LCH) for disaster-affected families since 1970. As on June 2012 CB provided shelter support for 377,687 families all over the country. Type of hazards is different and the people have cultural distinctions. Moreover, the natural resources are specifics from one site to other; therefore, the coping strategies for shelter are not same. Previously one particular model house design was prepared by the CB for all areas of Bangladesh. Some modifications were done from time to time. Disaster, geographical area, cultural aspects were also considered in some cases. Community people's opinions were sometimes taken into considerations for design of houses. But these were not adequate. Similarly Caritas Bangladesh constructed LCHs in Sidr 2007 affected areas having financial support from Secours Catholique/Caritas France. An evaluation was carried out in 2008 by International Centre for Earth Construction (CRAterre)-ENSAG for Caritas France supported houses. In the evaluation report, it was recommended that both the social and technical features of such houses should be improved. To this context, CB approached BUET to provide technical assistance towards their Low-cost Housing Project in Disaster-prone areas. CRAterre-ENSAG, France as a consultant to Caritas France also joined to provide technical support.

Upon successful completion of the CB implemented first phase of pilot LCH project in 2009-2010 Fiscal Year in Kuakata of Patuakhali and Sirajdikhan of Munshiganj district with financial support from Caritas France, CB took up its second phase (October 2011- September 2014) for other six regions of Bangladesh with funding support of Caritas France and Caritas Luxembourg wherein CRAterre-ENSAG and BUET are the technical partners for the project. Findings of the evaluation for first phase Pilot LCH Project

done in collaboration with BUET and CRAterre-ENSAG considered for the second phase project. The main objective of the project is to minimize the impact of recurrent disasters on LCH to ensure that people of disaster affected households live in disaster risk resilient houses. In the project, 30 types of LCH are being designed for 30 disaster prone areas, at the same time 60 pilot LCH are being constructed and 48 existing houses are repaired. Finally, the learning will be disseminated to the rural people, engineers, other NGOs and educators. This paper presents the findings of the completed first phase of the project.

2- Project Location

At the first phase of the project one area was selected in the cyclone prone area (Kuakata of Patuakhali district) and another area was selected in the flood prone area (Sirajdikhan of Munshiganj district). The project locations are presented in the map of Figure 2.

3- Design Strategies and Project Sequence

Project sequence has been presented in Figure 3. Three-stage community level meetings were held to collect local information and views of the people along with the artisans. Properties of the local construction materials were ascertained from laboratory tests. Considering the service and environmental loads, designs were finalized based on Finite Element Modeling (FEM). Model houses were constructed at the selected locations to demonstrate them to the local community with an aim that new design or at least some features would be replicated. Performances of these model houses are being monitored. The main aspects of development of disaster resistant housing consists of (i) survey, (ii) design, (3) construction and technical Improvement, (iii) dissemination of learning, (iv) follow up and monitoring.

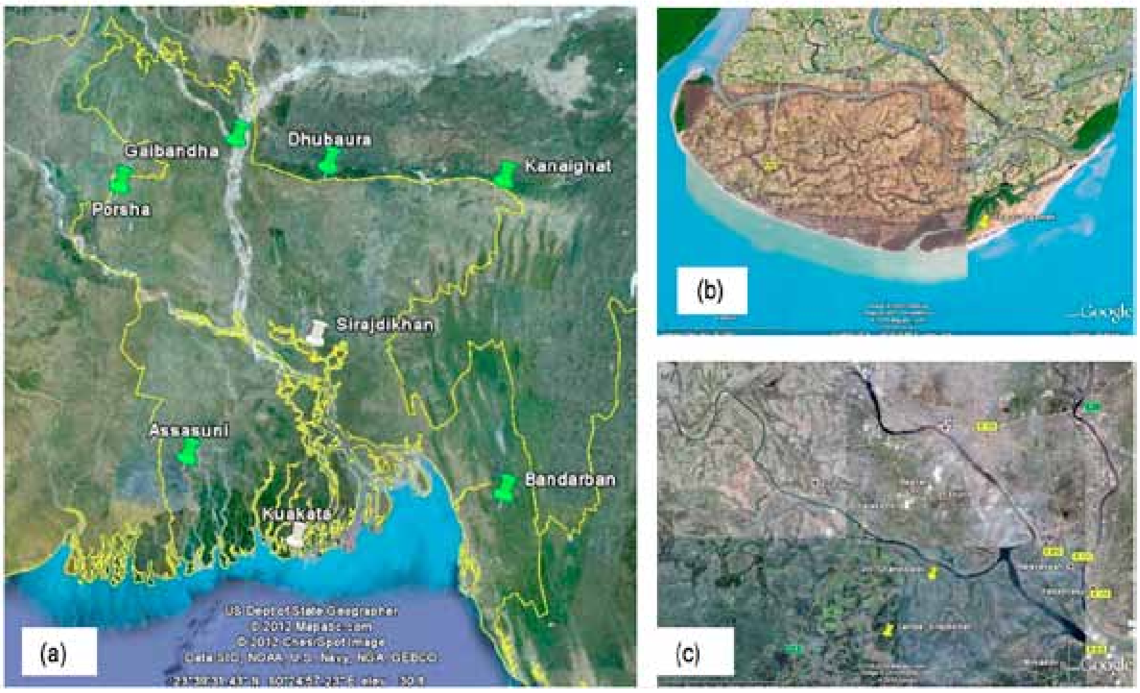


Figure 2: (a) Project locations on the map of Bangladesh; (b) close view of Kuakata and (c) close view of Sirajdikhan

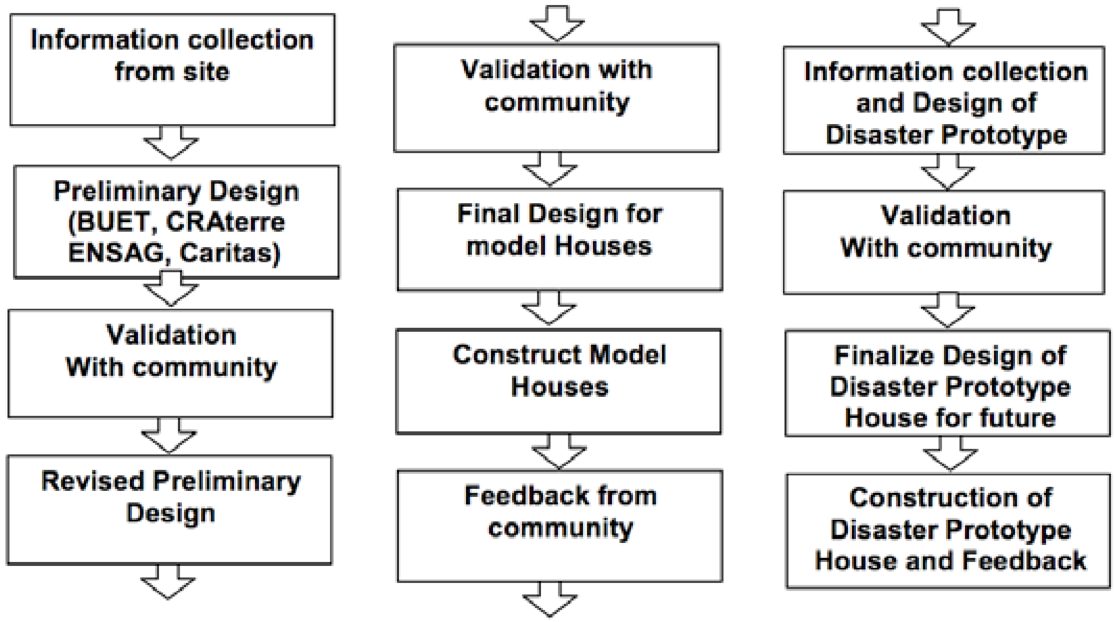


Figure 3: Project sequence followed in the project

3.1- Survey:

Following are the key features of the survey:

- Inform the local people about the LCH programme,
- Rapport building based on meeting with local authorities, community leaders, etc.,
- Development of survey formats for obtaining the social and technical information,
- Survey the types of existing houses, size, material costs and social map.,
- Community meeting to understand the overall situation in the village (social and economic conditions, including housing),
- Transect walk /observation and selection of houses to be assessed,
- Individual house assessment (technical and detailed),
- Meeting with artisans and people involved in the construction to understand types of houses and availability of artisans, materials, rates etc.,
- Analysis of the survey to determine the design strategy for different types of LCH.

3.2- Design Steps

- Main steps in the design followed:
- Preparation of preliminary design based on primary survey (BUET),
- Sharing among CB, BUET and CRAterre for feedbacks,
- Preparation of the draft design (BUET),
- Selection of treatment method for different elements of the structure (CB, BUET and CRAterre),
- Cost estimation (CB),
- Sharing the design with the community for their inputs (CB and BUET),
- Incorporate feedbacks and validation with community,
- Preparation of the final design (BUET).

3.3- Construction of Houses/ Shelter

- Formation of Project Committee (PC),
- Community-led beneficiaries selection (CB),
- Training of artisans (CB and PC),
- Selection of artisans (CB and PC),

- Procurement of materials (CB and PC),
- Treatment of materials (CB, artisans and PC),
- Organization of the house, position and space arrangement (CB, beneficiary, artisans and PC),
- Construction of 2 houses, one for each model (CB, PC, artisans and community),
- Validation of 2 houses for improvements (CB, BUET, PC, artisans, community and beneficiaries),
- Providing feedbacks for improvements (CB and BUET),
- Construction of the rest 2 houses (CB, PC, artisans and community),
- Improvement/ repair of houses.

3.4- Monitoring/Follow up phase

- During construction (CB and BUET),
- After construction: every 6 months (CB).

4- Design of LCHs

Proposed LCH design should respect local practice and culture. Information is collected to identify the client/beneficiary needs. And also the local mason, carpenter availability is given consideration.

4.1- Design in Cyclone-prone Area

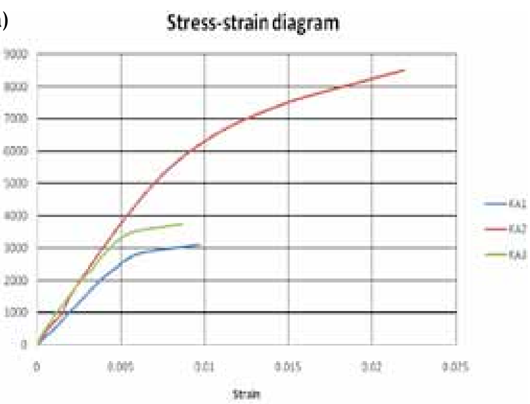
4.1.1- Design Considerations

A four pitched roof is selected for better wind resistance in the cyclone-prone area. As per BNBC, 1993 the house should be designed for 260 kmph Faster mile. However, as these houses are not alternative to cyclone shelter, a realistic compromise on wind speed had been reached. A RC and timber framing system, which is common in the area, is chosen. For the post, 1:2:4 concrete post reinforced with mild steel bars is selected whereas timber from locally available rain tree is used for beams and roof rafters. Timber properties have been ascertained from laboratory testing. A stepped earth plinth is chosen for better protection as the local soil is silty sand. Two parts of bamboo fences were used for better maintenance/repair of the lower part fence.

4.1.2- Material Testing

Soil, local building materials (wood, water) were tested at the BUET laboratory. Typical test results on wood sample (Rain Tree) are presented in Figure 4a. It can be seen that water content has significant effect on the strength of the wood. Figure 4b shows the failure pattern of a wooden beam during testing.

(a)



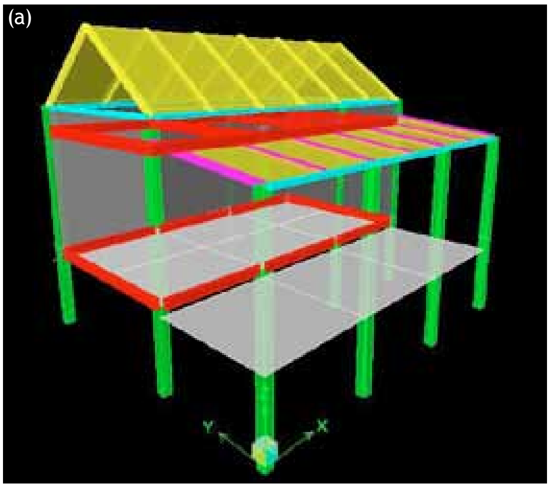
(b)

Figure 4. (a) Stress-strain relationships of wood in compression and (b) photograph of a failed sample in bending.

5.1.3 Finite Element Analysis

Based on the considerations, a 3-D finite element analysis was conducted (Figure 5a). The photograph of the Figure 5b shows the constructed house. FE analyses show that diagonal bracing would better resistant to wind. However, finally the due to construction difficulty, the diagonal bracings were changed to corner bracing as can be seen from Figure 5(b).

(a)



(b)

Figure 5. (a) 3-D finite element model of the proposed house in Kuakata; (b) photograph of completed house.

4.2- Design in Flood Prone Area

4.2.1- Design Considerations

A two pitched roof is selected for better wind resistance in the cyclone-prone area. As per BNBC, 1993 the house should be designed for 210 kmph Faster mile. However, a realistic compromise on wind speed had been reached. A RC and timber framing system, which is common in the area, is chosen. For the post, 1:2:4 concrete post reinforced with mild steel bars is selected whereas timber from locally available rain tree or mehagani is used for beams and roof rafters. Timber properties have been ascertained from laboratory testing. A stepped high earth plinth is chosen for better protection as the area is flood prone. Two parts of the bamboo fences are considered for better maintenance/repair of the lower part fence. A loft/mezzanine is provided to save valuables during flood.

4.2.2- Finite Element Analysis

Based on the considerations, a 3-D finite element analysis was conducted (Figure 6a). The photograph of the Figure 6b shows the constructed house.

5- Summary and Recommendations

1. About 60% families in Bangladesh live in LCH. This sort of infrastructure is easily damaged by natural disasters such as flood and cyclone. So, preparation for appropriate design and structure of LCH is a crying need of the day. It is a social responsibility of architects, engineers, educational institutions and civil society members to take positive initiatives for this issue. The main aspects of the research project are as follows:

2. In designing houses the level of hazard needs to be considered. It is important to use locally available materials and technology and show respect for local culture and practice. Importance must be attached to affordability, safety and replicability of the community.
3. Model houses are designed and constructed in two disaster prone areas of Bangladesh based on community participation. For designing the houses, local materials were chosen and the skill of local mason and carpenters were kept in mind.
4. The completed house performed well and these are well accepted by the local community. However, performances of the constructed houses are being monitored.
5. Caritas staff members should incorporate their knowledge and skills in disaster preparedness and emergency response activities. CB may propagate the acquired knowledge learning to national and international NGOs, government sectors and Caritas International partners.
6. Educational institutes like BUET and practicing engineers can incorporate the learning from the project into the building code, text book etc. Expansion of research regarding LCH and related topics will have to be included in the curriculum of the technical institutes and universities without delay.

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IX. CONCLUSION

The major result of the DRBC seminar, organized by CRAterre-ENSAG, lies first in a commitment to initiate a real change in working methods, particularly in encouraging all the actors concerned to “work together” so as to promote a collective disasters resistance strategy. This budding synergy and the promise to meet again are commanded by a reality that everyone can see for himself in his daily life and professional practices. The findings of the literature review conducted on the DRBC within CRATerre along with the work presented during the seminar show a convergence along the lines of a real interdisciplinarity, of an essential “way of making together” today in order to meet the challenges and face the threats represented by the ever increasing incidence of natural hazards and an ever greater vulnerability. This unique encounter has allowed us to highlight the following points:

- the disasters associated with natural hazards are both causes and consequences of various forms of economic and power inequalities inherent in the failure of the form of “development” induced by an unsuitable and unfair western model,
- the awareness of the environmental and social consequences of this failure led to imagine new key concepts (“sustainable development”, “citizen participation”, etc.) meant to reduce environmental degradation and poverty, i.e. factors that increase vulnerability. This “poverty” is not only economic but also cultural as it is induced by the disruption of a former cultural order.
- in a context dominated by a market economy and globalization, the prevailing system of risks reduction promotes and vindicates the interests of construction lobbies, but also of institutions and «experts» who obey a purely technocratic and bureaucratic logic, relying mostly on so-called “appropriate” sophisticated technologies and standardized materials even though these are not always technically, socially and economically available to the populations,
- until recently, conventional programs of post-disaster reconstruction have often done little to really reduce the vulnerability of affected populations and, consequently, to increase their resilience (autonomy, sustainable development, livelihoods, etc.). Moreover, their assessment is too often based on quantitative criteria and very fragmentary objectives (safety, economy, etc.). It is thus difficult to effectively analyse the impact of these programs over a long period,
- as they are implemented by a top-down managerial method, most of these programs bring about discontinuity and cultural erosion by demeaning local knowledge, craftsmanship and traditional businesses with the result that they ultimately jeopardize the poorest populations and make them even more vulnerable. They also - sometimes unwittingly - introduce new forms of exploitation by the relocation of cheap labour condemned to work under the same logical expertise, a method which further induces the disappearance of local practices and know-how. All such practices eventually lead to the gradual elimination of traditional technologies and practices that and to the destruction of the cultural environments in which they had developed an integrated approach to disasters.

Nevertheless, this seminar has also shown that approaches to risk reduction are changing. While until recently post-disaster approaches had been prominent, including sophisticated mechanisms for emergency response involving monitoring and alert systems based on new technologies, more attention is now paid to mitigation and preparation approaches that aim at increasing the resilience of communities. The contribution of social sciences (ethno-science, ethno-ecology, dwelling anthropology, etc.) has facilitated the introduction of these

new opportunities and the intervention of important international bodies that recognize the importance of local knowledge in strategies for pre-disaster preparation and risk reduction. These skills are beginning to be regarded as a «means» to supersede the institutionalized and "top-down" project management backed up by the supremacy of engineering sciences and instead foster "reasoned" and "reasonable" development. Conversely, as we have seen during the seminar, particularly with the work carried out on housing programs in Haiti (VIEUX-CHAMPAGNE & al ., 2013) and in Bangladesh (ISLAM & al., 2013), integrated engineering based on local cultures offers greater alternatives.

The evolution of literature and the changing paradigms mentioned above have allowed us to identify existing gaps and deficiencies in the integration of "living cultural heritage" in disaster preparedness and risk reduction. The contributors at the seminar have clearly shown that the use of local knowledge in the field of DRR is an additional tool for vulnerable communities. Conceptualizing "disaster resistant local cultures" as "cultural capital", shows that the conservation of tangible local heritage and the integration of the living dimension of cultural heritage are instrumental in reducing social and physical vulnerability. These assumptions have frequently underscored the validity and relevance of the concept of Disaster Resistant Building Cultures and practices (DRBC) and the theoretical foundation on which it is based.

In this context, an interdisciplinary convergence would be conducive to gather real information from the analysis of socio-economic and physical contexts (natural and built environment), and this is very precisely what clearly justifies the fact of bringing together the local and scientific knowledge. The objective would be therefore to deepen the understanding of DRBC, to disseminate knowledge, to develop methodologies to identify what is relevant and develop adaptable and easy-to-use fieldwork protocols.

Nevertheless, despite numerous declarations that vindicate sustainable development, respect for the rights of indigenous peoples and the preservation of local knowledge as a participatory management tool there is a need for a firmer commitment to adopt a more pragmatic approach if we do not want to see the notion of DRBC become an article of political correctness. It is in this perspective that the subversive and creative powers embodied in the DRBC help counter the hegemony of techno-bureaucratic logic. In addition, policies and territorial development strategies often rely on a notion of "vulnerability" in which social and physical dimensions are compartmentalized and removed from the complexities and realities on the ground. In the context of a wider awareness of the need to increase the resilience of communities and promote a "reasoned and reasonable" development, the DRBC approach represent a means of responding adequately to the needs and aspirations of the populations affected by disasters while promoting territorial policies which are likely to more successful if they heed socioeconomic, ecological and cultural interactions, and above all if they take local perceptions and advice into account.

Knowledge and power going hand in hand, the control that enables institutions to make decisions at the local level based on the exclusive knowledge of "experts" without involving the people concerned, and justifying these choices "for" their sake is a form of domination which can no longer be tolerated today. Assuming we want local communities, practitioners and scientists to work together through the study and implementation of the DRBC, a genuine partnership actually demands that we operate a radical political transformation of power relations. Indeed, we must never forget that the importance of the economic and social fabric of a given geographical area is determined not only by the type and amount of resources

that are available, but also by the cultural dimensions that underpin it. This refers to the unique nature of a society whose livelihood depends on the specificity and constraints of the local environment. Each culture has its own specificities and therefore its perception of risk responses, the way it internalizes them and faces them cannot be generalized. It is therefore necessary to consider these specificities as primordial and take them into account with respect to strategies for risk reduction.

Last but not least, we must ask ourselves if the important cultural bridge to be constructed lies in our ability to integrate analyses, modelling, design and tools from engineering, social and material sciences to the knowledge and practices constituting the DRBC? Or should we consider this integration as deleterious to the local cultures since they would entail the risk of dissolving them by cultural erosion and domination? Or, contrariwise, should our research lay more stress on the adaptation of “scientific” tools to local cultures and to the coproduction of knowledge? This approach would clearly emphasize the adaptability and inclusive potential of the DRBC and also highlight the complementarity and enrichment that the association of DRBC to the contemporary methods of investigation of social sciences represents for urban and regional planning, especially for the significant assistance it could bring to decision-making. By extension, the results of this seminar finally confirm that the conservation and re-use of DRBC are potentially important levers of empowerment and development.

The paths of research we have identified through the work done before and during the seminar are thus designed to further the social strategy that must necessarily be holistic and interdisciplinary and must therefore oppose the disintegration and fragmentation forces still at work in a as yet too powerful technocratic system.

IV. APPENDICES

1- ORIENTATION NOTE

2- DETAILED PROGRAMME

3- CONTRIBUTORS AND PARTICIPANTS DIRECTORY

1- ORIENTATION NOTE

Introduction

Major «natural» disasters and their social and economic impacts, often trigger passionate debates on the technologies, approaches and programmes to be implemented so as to achieve sustainable reconstructions that ensure the restoration and improvement of pre-disaster situations, thus reducing the impact of future natural hazards on populations and their properties, as well as improving local resilience.

Beyond all of the issues linked to the importance of the success of reconstruction programmes, it is even more relevant and necessary to understand how the adopted solutions may not only be effective in terms of increasing the safety of the people, their livelihoods and belongings, but also to contribute to the sustainable reduction of the vulnerability of populations facing hazards.

In this sense, local building cultures have demonstrated their value, firstly because they are founded on history, paying heed to risks on a local scale, but also because they offer the possibility of a better use of local resources and dynamics, and further ensure that their proper integration into current lifestyles and customs. At the same time, workers in the field appear to be confronted to objectives and strategies that are seemingly contradictory.

This seminar is a follow-up to the work achieved by many researchers, organizations and field workers. There are more and more actors from various fields making significant scientific or professional contributions, with often converging results, on the different aspects of local building cultures in general and disaster-resistant building cultures in particular. In a number of cases, bridges between the world of research and reconstruction programs have been created, to help reduce the vulnerability of concerned populations.

The purpose of this seminar is to summarize a state of knowledge, highlight actors, developments and trends, but also discuss the achievements and gaps to be filled in the field, identify priorities and, if necessary, allow the establishment of synergies. The dynamics of research around this work shared with other researchers and practitioners will be aimed at strengthening social strategies that should be holistic and transdisciplinary, and therefore oppose the trends of “dislocation” and “fragmentation” that define current technicist mindsets.

Preliminary study

In preparation for the seminar, a bibliographic synthesis was carried out, based mainly on a corpus of more than 600 non-exhaustive bibliographic references (publications, articles, etc.). This preliminary summary highlights the increasing number of studies on the subject as well as their diversity, and a growing interest it has elicited among an ever-growing number of researchers. This development is directly linked to the number of disasters and their impact, as well as the difficulties faced by affected populations and post-disaster reconstruction actors, in the achievement of satisfactory results. Under these conditions, many researchers and operators have expressed the need for a more comprehensive and a more consistent approach of prevention and disaster reduction matters, including the reduction of vulnerability.

After a first phase involving the identification of major stakeholders and a critical survey of written works, the methodology implemented for this preliminary work included the following main steps:

1. Study of current scientific literature (over the past 15 years, mainly):

- proceedings from conferences, international seminars, etc.,
- articles in scientific journals, magazines, newspaper articles, etc.,
- theses, studies, books, reports.
- 2. Analysis and Evaluation of the bibliography:
- based on the expertise and knowledge of the CRAterre – ENSAG team (current world situation and international projects),
- based on the use of existing computer tools and the design of a database dedicated to disaster-resistant building cultures (keywords, research instruments and statistics, etc.).

3. Definition of the state of research on the subject, according to different “clusters” and “themes”

This work focused on a preliminary analysis of 610 documents from which 175 references were pre-selected because of their relevance and source quality. They include 28 conference papers, 96 articles in scientific journals and publications, 12 theses, 13 reports, etc.

Findings

Natural hazards and disasters

In recent years, the number of disasters caused by natural hazards has greatly increased. An upward trend in the number of people affected is also noted (more than 200 million individuals affected every year since 1994)[1]. This is due to changes in demographics and urbanization, with a word population development from 5.7 to 7 billion people between 1995 and 2010.

The limits of a system

The effects of natural disasters are both the cause and the consequence of different forms of poverty, not only in economic terms, but also as regards culture, including disturbing alienation and acculturation phenomena. The weight of dominant systems and globalization tend to spread the following:

- sophisticated and high-tech solutions, together with so-called “appropriate” laws and rules,
- hyper-specialized techno-bureaucratic expertise and «top-down» approaches.

The application of such well-intentioned principles often leads to:

- the standardization of materials and techniques, even when unavailable locally (technically, socially and economically speaking);
- the devaluation and the dissolution and even the disappearance of local methods and solutions and therefore, of the technologies and practices that come from them and also

1 UN/ISDR, “Disaster Statistics,” UN/ISDR (2007), http://www.unisdr.org/disaster-statistics/occurrence-trends-century.htm. EM-DAT: The OFDA/CRED International Disaster Database, Brussels, Belgium: Universite Catholique de Louvain, 2007: http://www.em-dat.net

their environment,

- a certain level of disqualification of traditional artisans and local entreprises,
- and finally, too often, the precarization and vulnerabilization of populations, especially of those most in need.

Strategies for disaster risk reduction

The most recent evaluations suggest the following:

- quite often, post-disaster reconstruction programmes do little to increase the resilience of affected populations or reduce their vulnerability (in terms of autonomy, sustainable development, livelihoods, etc.)[2],
- because of the increased risks posed by natural hazards, there is an urgent need to develop new strategies to improve risk reduction strategies3,
- it is necessary to mobilize different types of knowledge, multiple and interdependent: local knowledge and traditional skills, possibly associated with consistent and compatible contemporary knowledge and practices, which may be useful in the process of documenting, characterizing, revealing and "recycling" traditional practices.

The recent context of development of studies on indigenous knowledge

Local knowledge and know-how has been one of the major areas of study of ethno-ecology since the 1950s: little by little, "knowledge and indigenous knowledge" are no longer be viewed as "backward" or "outdated and filled with superstitions"[4].

But the relationships between science and indigenous/local/eco-friendly/traditional knowledge (which are still "fuzzy" notions and sources of disagreement) generate debate. Paradigm shifts are taking place, including the observation that local knowledge and intelligence are better adapted to their environment and much more flexible than "appropriate" technologies. But the question of the integration of such knowledge, in scientific and economic terms, remains to be fully explored on a larger scale.

The adoption of the Convention on Biological Diversity[5] at the Earth Summit in Rio de Janeiro in 1992 brought about new developments which were instrumental in the evolution of the study by fostering both the confrontation and the the association between scientific and indigenous knowledge.

This evolution facilitated the work of researchers and NGOs working on building cultures, and for some of them since the 1970's. Concepts related to "building cultures", "risk cultures" and the "reduction of vulnerability to disasters through the application of indigenous knowledge" become increasingly visible in both the technical and scientific literature.

However, while a number of professionals, researchers and institutions today are convinced of

2 *TWIGG, 2006.*

3 *Baumwoll, 2008.*

4 *MISTRY, 2009: 372*

5 www.cbd.int/doc/legal/cbd-en.pdf *(articles 8J and 15)*

the need to take into account local building cultures, disparities still obtain and many improvements remain to be made. The seminar, therefore, addresses widely shared concerns in the scientific community and among field workers.

Reasons for interest in local "disaster-resistant building cultures"

In recent years, changes regarding the approaches to disaster risk reduction (DRR) occurred, with an introduction to vulnerability approaches that focus on disaster preparedness, as well as the inclusion of affected populations in the process and as part of "community-based disaster management", which aim to strengthen the resilience of affected communities.

A process of reduction and risk prevention based on "disaster-resistant building cultures" may generate and strengthen the following:

- going beyond industrial and industry-centered paradigms,
- emphasizing capacities and enabling decision-making over strategic and technical choices at local levels (post-disaster responses, emergency, (re)construction, development, etc.),
- increasing respect and recognition of the historical, living, tangible and intangible values present in local building cultures that may be the heritage of affected populations,
- a better combination of systems for risk reduction: beneficial exchanges and sharing between systems, scientific knowledge/indigenous knowledge (building and management related knowledge, etc.),
- the integration of empowerment[6] as a concept enabling populations to acquire greater control over decisions affecting their own lives,
- the integration of «living heritage» as part of the understanding of traditional indigenous knowledge and cultural heritage,
- the emergence of a paradigm linked to the «management and prevention of risks in living and cultural heritage»[7].

However, many obstacles and deficiencies continue to be observed and many areas deserve further research and improvements, mainly due to the following facts:

- regulations are sometimes incompatible with the application of indigenous knowledge (e.g. construction norms, property rights),
- there is a lack of knowledge on decision-making mechanisms at different levels and of the methods to address this issue,
- difficulties in understanding the behaviour of some building systems through modern scientific and engineering methods and difficulties in modelling these complex systems,
- the scarcity or non-existence of studies delaying the identification and development of local alternative solutions, different from international standards, based on the development of specific indigenous knowledge.

6 *Labonte & Laveracq, 2000*

7 *Jigyuasu, 2004*

Scope of seminar approach

An approach centered on pre- and post-disaster management practices, contextually integrated, implies the deployment of social and collective organizational skills within a community, involved in the analysis, prevention and local risk management, through:

1. Strategies of prevention and mitigation:

- alert,
- avoidance or escape,
- education,
- land use planning.

2. Collective support

- construction of collective shelters,
- spatial organization,
- mutual aid.

- 3. Building disaster-resistant structures
- preventive systems (traditional, vernacular, indigenous, «conventional»)
- or improved systems for a better tomorrow: from reconstruction to prevention.

Recommendations

Preliminary suggestions for research themes:

1. Knowledge, History and Atlas of DRBC,

2. Transfer of knowledge : from an intangible and non-formal acquisition to an institutional supervision,

3. Characterization and modelling / Integrated approach to engineering,

4. Communities and DBRC research : potentials and limitations (or “how to bridge the gaps that separates the academic world and the affected populations?),

5. Terms and methodologies for the integration of DRBC as part of the risk preparedness and the implementation of appropriate intervention strategies.

It would also be interesting and important that the seminar should lead to real proposals allowing:

- fundamental research,
- applied research,
- outreach programmes / dissemination of results.

Illustration 8- the participants and contributors at l'Isle d'Abeau earth village filed trip (Credit : Mauricio CORBA BARRETO)

2- DETAILED PROGRAMME

Monday 27 May 2013 - Morning programme

Time		Speakers/moderators
9:00	Registration	
9:30	**Welcome from the head of the AECC LABEX project and of the co-director of the AE&CC research unit of the School of Architecture**	Thierry Joffroy Anne Coste
9:40	**Seminar introduction**	Philippe Garnier
9:50	**Disaster Resistant Building Cultures: a tentative state of knowledge and perspectives**	Etienne Samin

10:00	Round table 1 : Historical and Archaeological approaches	Philippe Garnier
10:05	**The contribution of Archaeosismicity to the knowledge of traditional hazard resistant constructions**	Georgia Poursoulis
10:15	**SEISMIC-V | Vernacular Seismic Culture in Portugal**	Mariana Correia
10:25	**Earthquake resistant design of traditional building cultures in Nias, Indonesia**	Petra Gruber
10:45	**Traditional is Modern**	Randolph Langenbach
10:55	Questions to speakers and debate	
11:35	**Coffee break – Amphi du Parc**	

11:50	Round Table 2: Technical aspects and Engineering sciences	Georgia Poursoulis
11:55	**Effectiveness and fallout of seismic retrofits in the traditional building cultures**	Ugo Tonietti Luisa Rovero
12:05	**Architecture parasismique en bambou : faire danser les maisons ?**	Iris Legrand
12:15	**Learning from earthquakes: A field study exploring the seismic damages on "horizontal timber lacing masonry" vernacular buildings.**	Milo Hofmann
12:25	**Seismic vulnerability analysis of traditional haitien timber frame structures with earth infilling**	Laurent Daudeville
12:35	Questions to speakers and debate	
13:15	**Lunch – Amphi du Parc**	

Monday 27 May 2013 - Afternoon programme

14:15	*Round Table 3: The social demand and the contributions Human and Natural Sciences*	*Olivier Moles*
14:25	***Distressed Urban Fabric, Disaster resistant building culture and Development Animators***	*Reiza Sheikh*
14:35	***Ethno ecological contribution to the study of disaster resistant building cultures: the case of Cap-Haitian, Haiti.***	*Léa Genis*
14:45	***Order of things, meaning of the world : social aspects of the post catastrophe (re)construction life***	*Ludvina Colbeau-Justin*
14:55	***Exploring local disaster-resilient building practices as starting point for vulnerability reduction strategies***	*Annalisa Caimi*
15:05	***Improvement of rural housing for disaster prone areas in Bangladesh: experience of Caritas Bangladesh***	*Jyoti F. Gomes* *Shariful Islam*
15:15	*Questions to speakers and debate*	
15:40	***Coffee break – Amphi du Parc***	

16:05	***Perspectives and General framework.***	*Philippe Garnier*
16:15	***General debate about the way forward for future researches on disaster resistant building cultures.***	
17:40	***Conclusions and organisation of the next day seminar.***	

18:05	*End of the first day of the seminar*	
19:30	***Diner at la gueule du loup (near to the school of architecture)***	

Tuesday 28 May 2013

9:00	***Working group sessions***	*Working group*
11:00	***Coffee break – Laboratoire CRAterre***	

11:15	***Working Group sessions – conclusion and preparation of reporting***	*Working group*
11:30	***Intermediary presentation of working group sessions to the general audience and debates***	All
13:00	***Lunch – Salle 289***	

14:00	***Working Group session – finalisation and complementary work***	*Working group*
15:00	***Final presentation of Working Group outputs and debates***	All
15:30	***Coffee break – Laboratoire CRAterre***	

16:00	***Final presentation of Working Group outputs and debates***	All
17:00	***General discussion and writing of synthesis elements and conclusions of Seminar***	All

18:00	*End of the seminar*	
19:30	***Departure from the hotel to the restaurant " La Brasserie des fleurs" (city center)***	

Wednesday 29 May 2013

08:30: Departure from the school of architecture to the Domaine de la Terre.

09:45: Arrival at le Domaine de la Terre.

11:00: Departure to Les Grands Ateliers for the festival Grains d'Isère.

11.15: Arrival at les Grands ateliers.

12:30: Lunch (meal tray offered by the research unit AE&CC).

Feel free to visit all the workshops and the other events during the afternoon.

17:00: Departure from les Grands Ateliers to Grenoble.

18:30: Arrival at the school of architecture.

3- CONTRIBUTORS AND PARTICIPANTS DIRECTORY


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Illustration 9- ice-breaking time (Credit : Mauricio CORBA BARRETO)

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Illustration 10- Liste des participants au séminaire CCPP des 27 et 28 mai 2013 (Source : Laura DÉPIERRE, CRATerre)